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Proceedings of the IRE

IRE INTERNATIONAL CONVENTION

MARCH 21-24

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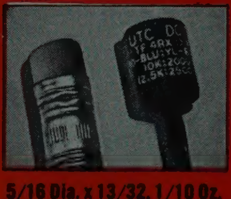
Revolutionary transistor transformers hermetically sealed to MIL-T-27A Specifications.

UTC DO-T and DI-T transistor transformers provide unprecedented power handling capacity and reliability coupled with extremely small size. Comparative performance with other available products of similar size are shown in the curves (based on setting output power at 1 KC, then maintaining same input level over frequency range). The new expanded series of units cover virtually every transistor application.

DO-T

ACTUAL SIZE



5/16 Dia. x 13/32, 1/10 Oz.

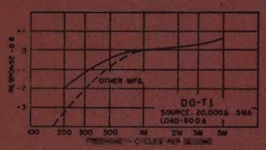
- **High Power Rating** . . . up to 100 times greater.
- **Excellent Response** . . . twice as good at low end.
- **Low Distortion** . . . reduced 80%.
- **High Efficiency** . . . up to 30% better.
- **Moisture Proof** . . . hermetically sealed to MIL-T-27A.
- **Rugged** . . . completely cased.
- **Anchored Leads** . . . withstand 10 pound pull test.
- **Printed Circuit Use**...plastic insulated leads.

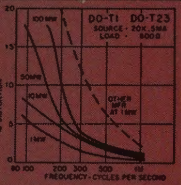
DI-T

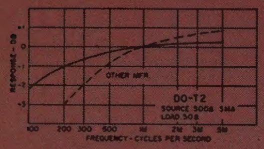
ACTUAL SIZE

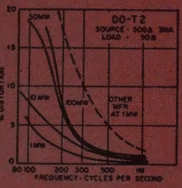
UTC DI
TF4RX

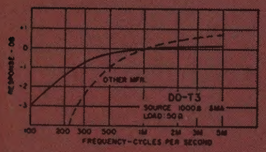
5/16 Dia. x 1/4, 1/

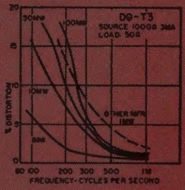


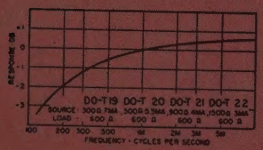


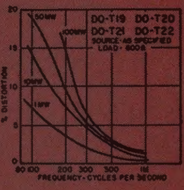


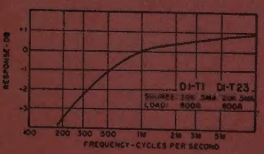


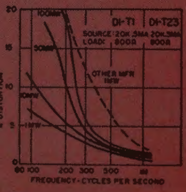


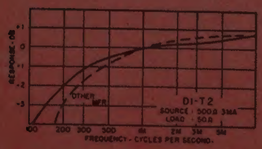


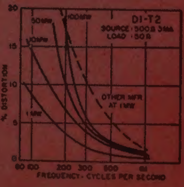


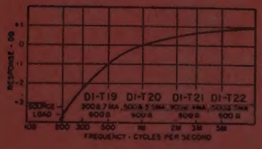


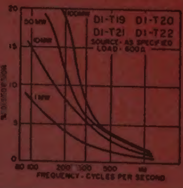












DO-T No.	MIL Type	Application	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Level Mw.
DO-T1	TF4RX13YY	Interstage	20,000 30,000	.5 .5	800 1200	850	815	50
DO-T2	TF4RX17YY	Output	500 600	3 3	50 60	60	65	100
DO-T3	TF4RX13YY	Output	1000 1200	3 3	50 60	115	110	100
DO-T4	TF4RX17YY	Output	600	3	3.2	60		100
DO-T5	TF4RX13YY	Output	1200	2	3.2	115	110	100
DO-T6	TF4RX13YY	Output	10,000	1	3.2	790		100
DO-T7	TF4RX16YY	Input	200,000	0	1000	8500		25
DO-T8	TF4RX20YY	Reactor 3.5 Hys. @ 2 Ma. DC, 1 Hy. @ 5 Ma. DC				630		
	TF4RX20YY	Reactor 2.5 Hys. @ 2 Ma. DC, .9 Hy. @ 4 Ma. DC					630	
DO-T9	TF4RX13YY	Output or driver	10,000 12,000	1 1	500 CT 600 CT	800	870	100
DO-T10	TF4RX13YY	Driver	10,000 12,000	1 1	1200 CT 1500 CT	800	870	100
DO-T11	TF4RX13YY	Driver	10,000 12,000	1 1	2000 CT 2500 CT	800	870	100
DO-T12	TF4RX17YY	Single or PP output	150 CT 200 CT	10 10	12 16	11		500
DO-T13	TF4RX17YY	Single or PP output	300 CT 400 CT	7 7	12 16	20		500
DO-T14	TF4RX17YY	Single or PP output	600 CT 800 CT	5 5	12 16	43		500
DO-T15	TF4RX17YY	Single or PP output	800 CT 1070 CT	4 4	12 16	51		500
DO-T16	TF4RX13YY	Single or PP output	1000 CT 1330 CT	3.5 3.5	12 16	71		500
DO-T17	TF4RX13YY	Single or PP output	1500 CT 2000 CT	3 3	12 16	108		500
DO-T18	TF4RX13YY	Single or PP output	7500 CT 10,000 CT	1 1	12 16	505		500
DO-T19	TF4RX17YY	Output to line	300 CT	7	600	19	20	500
DO-T20	TF4RX17YY	Output or line to line	500 CT	5.5	600	31	32	500
DO-T21	TF4RX17YY	Output to line	900 CT	4	600	53	53	500
DO-T22	TF4RX13YY	Output to line	1500 CT	3	600	86	87	500
DO-T23	TF4RX13YY	Interstage	20,000 CT 30,000 CT	.5 .5	800 CT 1200 CT	850	815	100
DO-T24	TF4RX16YY	Input (usable for chopper service)	200,000 CT	0	1000 CT	8500		25
DO-T25	TF4RX13YY	Interstage	10,000 CT 12,000 CT	1 1	1500 CT 1800 CT	800	870	100
DO-T26	TF4RX20YY	Reactor 6 Hy. @ 2 Ma. DC, 1.5 Hy. @ 5 Ma. DC				2100		
	TF4RX20YY	Reactor 4.5 Hy. @ 2 Ma. DC, 1.2 Hy. @ 4 Ma. DC					2300	
DO-T27	TF4RX20YY	Reactor 1.25 Hy. @ 2 Ma. DC, .5 Hy. @ 11 Ma. DC				100		
	TF4RX20YY	Reactor .9 Hy. @ 2 Ma. DC, .5 Hy. @ 6 Ma. DC					105	
DO-T28	TF4RX20YY	Reactor .3 Hy. @ 4 Ma. DC, .15 Hy. @ 20 Ma. DC				25		
	TF4RX20YY	Reactor .1 Hy. @ 4 Ma. DC, .08 Hy. @ 10 Ma. DC					25	
DO-T29	TF4RX17YY	Single or PP output	120 CT 150 CT	10 10	3.2 4	10		500
DO-T30	TF4RX17YY	Single or PP output	320 CT 400 CT	7 7	3.2 4	20		500
DO-T31	TF4RX17YY	Single or PP output	640 CT 800 CT	5 5	3.2 4	43		500
DO-T32	TF4RX17YY	Single or PP output	800 CT 1,000 CT	4 4	3.2 4	51		500
DO-T33	TF4RX13YY	Single or PP output	1,060 CT 1,330 CT	3.5 3.5	3.2 4	71		500
DO-T34	TF4RX13YY	Single or PP output	1,600 CT 2,000 CT	3 3	3.2 4	109		500
DO-T35	TF4RX13YY	Single or PP output	8,000 CT 10,000 CT	1 1	3.2 4	505		500
DO-T36	TF4RX13YY	Isol. or Interstage	10,000 CT	1	10000 CT	950	970	500

DO-TSH Drawn Hipermalloy shield and cover for DO-T's, provides 25 to 30 db shielding, for DI-T's DI-

‡DCMA shown is for single ended useage (under 5% distortion—100MW—1KC) . . . for push pull, DC can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC)

*DO-T units have been designed for transistor application only . . . not for vacuum tube service. Pats. Pe

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VOLUME 48, NUMBER 3

March, 1960

published monthly by The Institute of Radio Engineers, Inc.

Proceedings of the IRE®

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Proceedings of the IRE®

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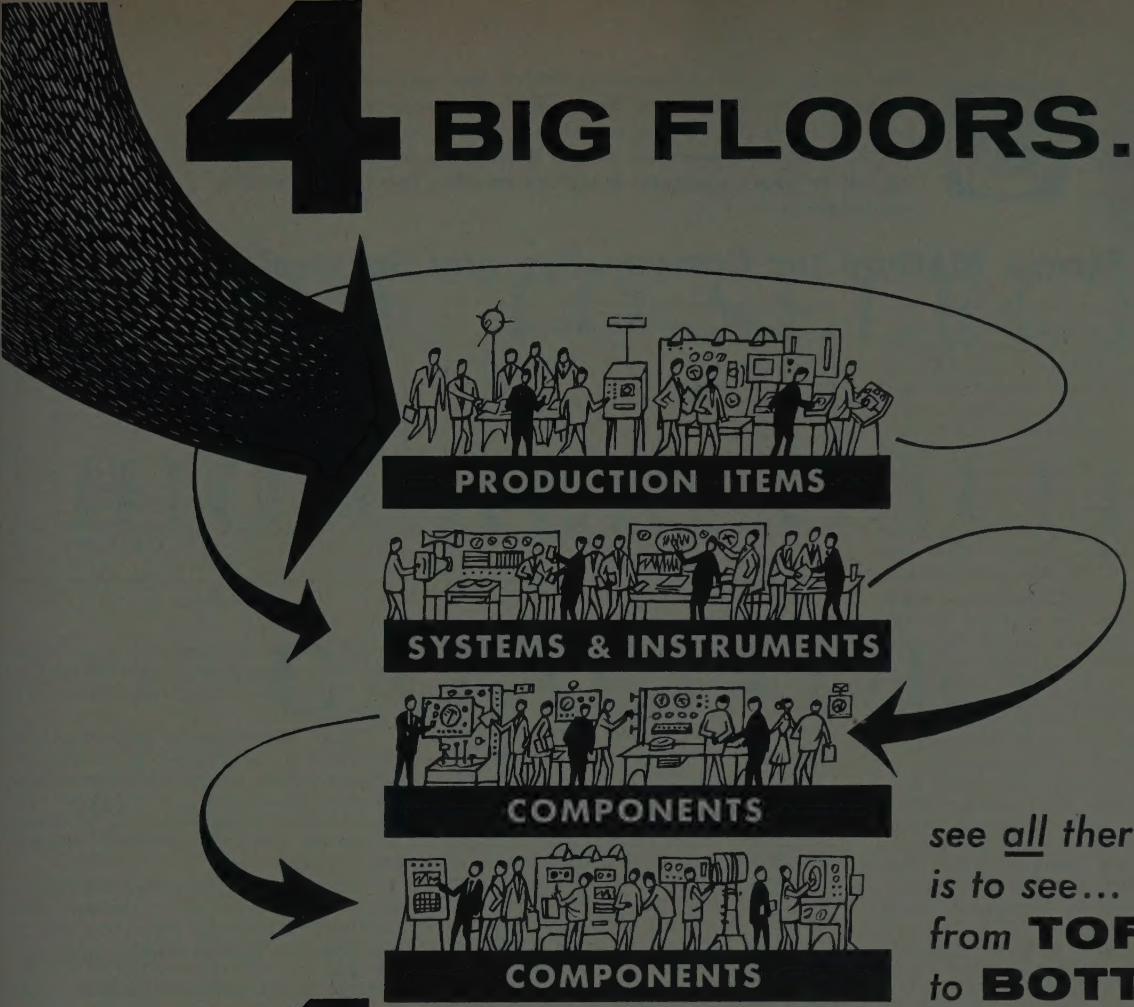

see *all* there
is to see...
from **TOP**
to **BOTTOM**

4 BIG DAYS...

at the IRE NATIONAL CONVENTION and RADIO-ENGINEERING SHOW!

It doesn't matter *how* you manage it – by starting at the fourth floor with Production Items, on to the third floor for Systems and Instruments, then down to Two and One for Components – or the reverse – what does matter is that you see ALL there is to see at the IRE National Convention and Radio-Engineering Show at the New York Coliseum, March 21-24. You could even take in one floor a day! Remember, there are 4 BIG FLOORS . . . and 4 BIG DAYS . . . so, plan your trips to the Coliseum so that you don't miss anything.

The opportunity to see SO MUCH that's NEW in the radio-engineering field comes but once a year with this giant IRE National Convention and Radio-Engineering Show. Be UP on your field with a thorough knowledge of the displays and exhibits that will be shown as NEW IDEAS in RADIO-ELECTRONICS, from the *top* fourth floor to the *bottom* first floor, at the New York Coliseum!

MARCH 21, 22, 23, 24

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Waldorf-Astoria Hotel

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Coliseum, New York City

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The series of advertisements which we recently ran in this space on the subject of Reliability was very well received, judging from the letters which were sent to us. This month W. A. Jasson, a member of the Reliability Group that is assigned to space projects, describes another facet of reliability engineering.

Step-Stress Method for Comparative and Survival Evaluation

We who struggle with weapons systems development and allied anxieties have a number of problems in common. One of the most difficult of these is the selection of component parts and circuits such that the probability of system survival (reliability) is maximized. This problem also calls attention to another: how to evaluate the probability of system survival in the first place. Since few answers are in prior data or the literature, we can resort to an economical and meaningful experimental procedure: step-stress testing. This can yield significant results with small samples.

In the step-stress technique of comparative evaluation and survival testing, malfunctions are induced in the test subject. The procedure is to select and apply stresses related to the system mission of such type and first-level magnitude as are likely to be withstood by all parts in our tests. After applying such a first-level stress, we take pertinent measurements of its effects. We then raise this stress to a pre-determined higher level and take measurements again. The process continues as stresses are increased in steps and the effects observed and analyzed. When the number of malfunctions caused increases to a point considered adequate (or the maximum practicable) for the purposes of the test, step-stressing ends (assuming all relevant stresses have been stepped) and we are ready for analysis of results.

Stresses applied in these step-stress tests can be divided into two categories: environmental and electrical. The sequence of (and within) these categories must be decided in the light of system and parts requirements. For a missile-borne system, it makes sense to start with environmental stresses, since these occur in storage and handling, and they attend the launching, usually preceding electrical stresses. First of the environmental stresses to apply are shock and vibration, which, although not always encountered first, are apt to yield more information than the others.

For the mathematical evaluation of environmental step-stress test data, most value will be found in significance tests which are often supplemented by regression analyses (particularly comparing pre-stress and post-stress values) and correlation. For life test data, the most useful calculations involve significance tests, hazard rates (failures/million hours in a convenient unit), and mean-time-to-failure (the reciprocal of the hazard rate). If step-stress test analyses are to be strictly valid, we must assume that the probabilities of failure of the units under test do not permute as stress level changes (see Figure 1). If this assumption is false, a part having a high failure rate at a high stress level may be stronger than its competitors are at more relevant stress levels. We must also be sure that the stress types are pertinent to the system mission and conditions, and that each stress (regardless of level) is applied in accordance with all environmental and electrical test specifications applicable for single-level tests. One should also consider the relative importance of fatigue and one-shot failure factors in the actual system application. The selection of stress levels should reflect the balance of significance of these two factors. Thus, if fatigue is the over-riding consideration, it would tend to show up better if the earlier stress levels are much closer together than would be desirable were one-shot failure the paramount problem.

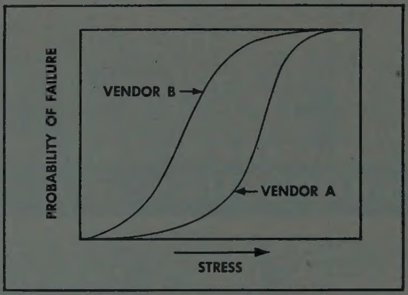

Figure 1

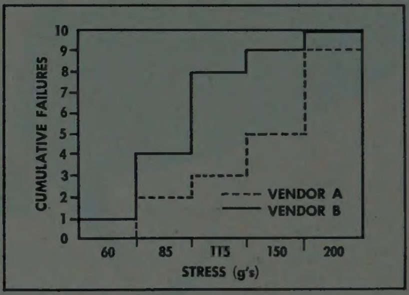

Figure 2

Let us consider the comparative evaluation of three manufacturers' versions of a particular type of silicon switching transistor. This transistor is to be used in a missile-borne system. Suppose we have determined the limit values of those transistor characteristics necessary for proper operation of the circuit. These characteristics would probably include pulse DC beta (h_{FE}), collector cut-off current (I_{CBO}), switching time, and saturation resistance. We can class as failures those transistors which change such that their characteristics move outside these limit values. Naturally, failures of this nature must be considered in addition to any catastrophic failures (shorts, opens, or characteristics values approaching these conditions). Since the system is to be missile-borne, we shall tackle shock and vibration stressing first. Figure 2 shows both the shock stress steps used and the corresponding number of cumulative failures resulting. The shock stress steps served as the basis for proportionate increments in vibration level. Whereas the results at the highest and lowest shock levels may not be significant, the large differences at the middle levels indicate that vendor A is superior.

In general, note that in running tests such as these, the usual procedure would be to alternate shock and vibration stresses. The shock stresses themselves should be applied in both directions along two or three axes in the usual manner. The application of vibration and all other stresses should also be as usual. If a particular step-stress level should cause all parts to fail, the test may have to be re-run using a lower level.

Other environmental tests also lend themselves to step-stressing, particularly thermal cycling, wherein we widen in steps the temperature limits of the cycles. An alternative, or a supplement, to this would be thermal shock step-stressing, which is more severe.

Turning now from environmental to electrical step-stress tests, their basic principle is very much the same. In electrical step-stressing, we step up, on a given time schedule, the electrical load upon the devices under test. A load so stepped may be in terms of power dissipations, applied voltages or currents, or both, depending upon (1) applicable component-part specifications of the manufacturer or of the project, (2) circuit or system specifications, or (3) knowledge of failure points of the part or circuit. The mathematical analysis of electrical step-stress test results is the same as for environmental results and life test as discussed above.

From all the foregoing, perhaps it can be seen that step-stressing is really a logical extension of single-level stress tests aimed at providing survival information for analysis or comparison of entities with respect to a particular electronic system. The step-stress technique yields accelerated failures. For any effective reliability effort, which normally includes comparative evaluation and/or survival testing, proficiency in the art and science of applying step-stress techniques is rapidly becoming a prerequisite to success.

A complete bound set of our third series of AIL Monographs is available on request. Write to Harold Hechtman at AIL for your set.

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HOW TO SELECT HIGH RELIABILITY CAPACITORS

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Check the record before you choose

The only sound approach to evaluate these claims is to investigate the *reliability record* achieved by each of the companies under consideration. Remember, it takes test data to establish the reliability of a product. Claims are not enough.

Now let's look at the record

Sprague Electric can substantiate its claim that its HYREL® Q Capacitors are "the most reliable capacitors made" with the most extensive test data available in the entire electronic industry. The performance of HYREL Q Capacitors is virtually impossible to surpass . . . now and for some years to come.

But let's start at the beginning—*the specifications.* Sprague Electric's high reliability capacitors were originally made under Sprague Electric Specification PV-100—*the first high reliability capacitor specification for missiles and other critical applications.* This specification and a later revision, PV-100A, have proven so comprehensive and so successful in providing "the highest order of reliability known to capacitor manufacturing" that their provisions are currently reflected in *every* military specification covering high reliability capacitors. This is a distinction shared by no other capacitor manufacturer.

Now look at the record of HYREL Q Capacitors

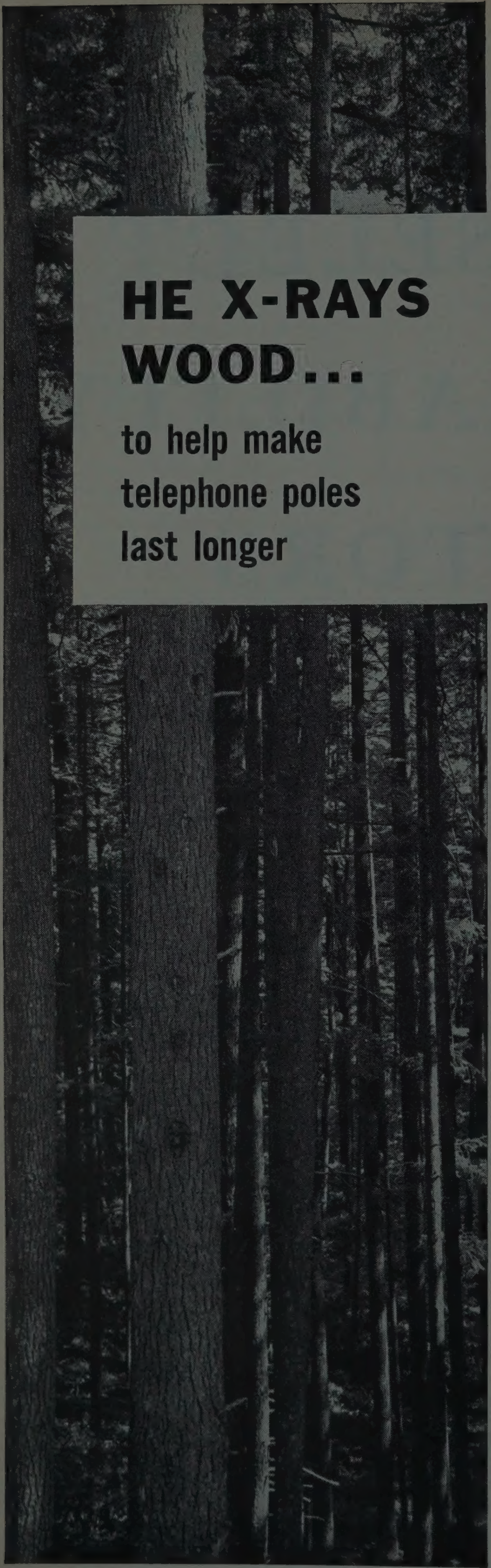
On accelerated life tests the failure rate of HYREL Q Capacitors has been less than 0.05%, after more than 16 million unit hours accumulated on tests of 250 hours at 140% rated voltage, 125 C. On high frequency vibration tests, there hasn't been a single failure in the more than 50,000 units tested. On seal, moisture resistance, and temperature cycling and immersion tests, the failure rate has been less than 0.1%.

Such performance from production line capacitors can only be achieved through the most intensive (and expensive) kind of reliability program—in design and development, in production engineering, in manufacturing facilities, in testing intensity and extensity—all of which should be investigated thoroughly.

After you've checked the record, then decide for yourself which capacitor is "the most reliable made."

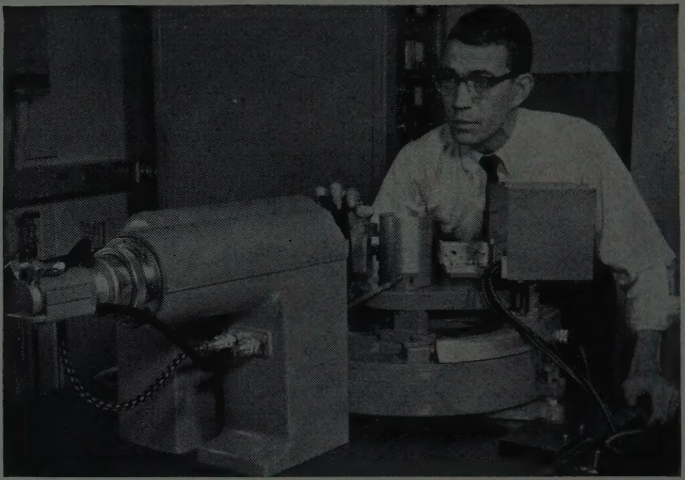
For complete facts and figures on HYREL Q Capacitors, call your Sprague District Office or Representative, or write for HYREL Bulletin 2900A and Specification PV-100A to Technical Literature Section, Sprague Electric Company, 235 Marshall St., North Adams, Massachusetts.

SEE US AT THE IRE SHOW—BOOTHS 2416-2424



HE X-RAYS WOOD...

to help make telephone poles last longer



Chemist Jack Wright developed the use of this X-ray fluorescence machine for testing the concentration of preservatives in wood. Here he bombards a boring from a test telephone pole with X-rays.

This Bell Labs chemist is using a fast, new technique for measuring the concentration of fungus-killing preservative in telephone poles.

A boring from a test pole is bombarded with X-rays. The preservative—pentachlorophenol—converts some of the incoming X-rays to new ones of different and characteristic wave length. These new rays are isolated and sent into a radiation counter which registers their intensity. The intensity in turn reveals the concentration of preservative.

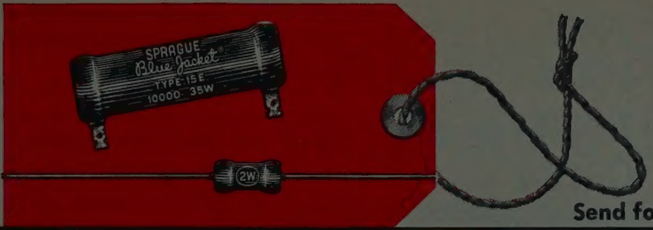
Bell Laboratories chemists must test thousands of wood specimens annually in their research to make telephone poles last longer. Seeking a faster test, they explored the possibility of X-ray fluorescence—a technique developed originally for metallurgy. For the first time, this technique was applied to wood. Result: A wood specimen check in just two minutes—at least 15 times faster than before possible with the conventional microchemical analysis.

Bell Labs scientists must remain alert to *all* ways of improving telephone service. They must create radically new technology or improve what already exists. Here, they devised a way to speed research in one of telephony's oldest and most important arts—that of wood preservation.

Nature still grows the best telephone poles. There are over 21 million wooden poles in the Bell System. They require no painting, scraping or cleaning; can be nailed, drilled, cut, sawed and climbed like no other material. Scientific wood preservation cuts telephone costs, conserves valuable timber acres.

BELL TELEPHONE LABORATORIES

World Center of Communications Research and Development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Blue Jacket
TYPE 15E
10000 35W
2W

BLUE JACKET®

VITREOUS ENAMEL-PROTECTED, POWER WIREWOUND RESISTORS.

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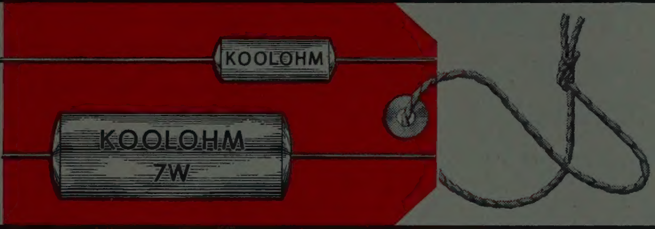
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KOOLOHM
7W

KOOLOHM®

CERAMIC INSULATED-SHELL, POWER WIREWOUND RESISTORS.

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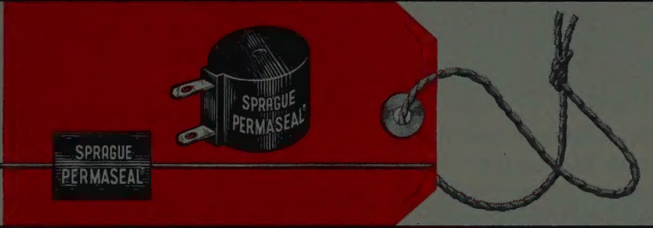
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PERMASEAL®

CAST EPOXY HOUSING, PRECISION WIREWOUND RESISTORS.

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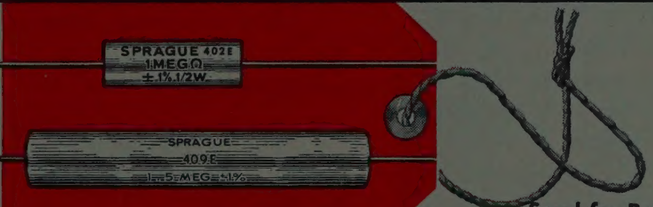
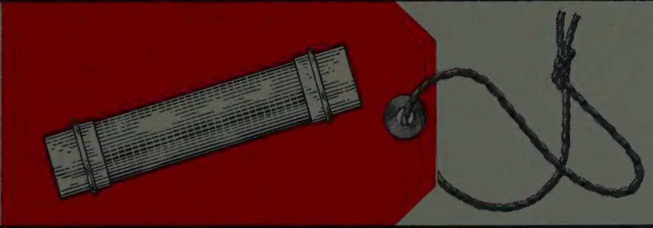

SPRAGUE 402E
1MEGΩ
±1% 1/2W
SPRAGUE
409E
1.5 MEG ±1%

FILMISTOR®

PRECISION CARBON FILM RESISTORS.

Send for Bulletins: 7000 (Molded shell), 7010-B (Ceramic shell)



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GLASS-JACKETED HIGH VOLTAGE, HIGH POWER RESISTORS.

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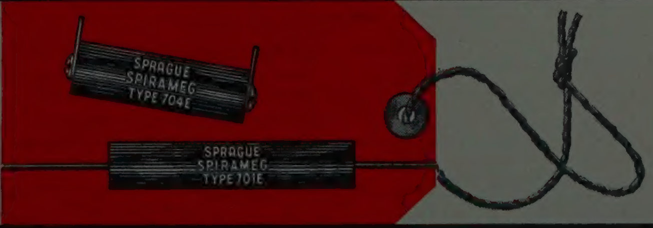
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SPIRAMEG
TYPE 704E
SPRAGUE
SPIRAMEG
TYPE 701E

SPIRAMEG®

HIGH-RESISTANCE SPIRAL ELEMENT RESISTORS.

Send for Engineering Bulletin: 7100

SPRAGUE ELECTRIC COMPANY 235 Marshall Street North Adams, Mass.

SPRAGUE COMPONENTS: RESISTORS • CAPACITORS • MAGNETIC COMPONENTS • TRANSISTORS
INTERFERENCE FILTERS • PULSE NETWORKS • HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

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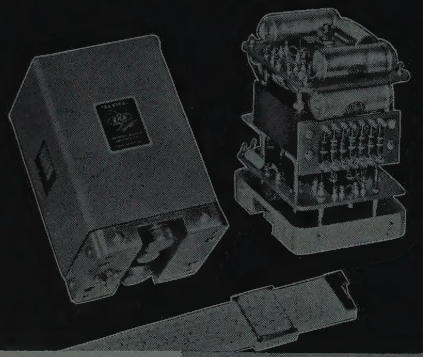
HIGH CURRENT
Miniaturized
TRANSPAC®

NEW SOLID STATE SHORT-CIRCUIT AND TRANSIENT PROOF POWER PACKS



Featuring ERA's New "Thermo-guide"® principle for minimum heat rise, size and weight.

FEATURES:

- New High Current Solid-State Designs
- Battery Voltage Outputs
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- Short-Circuit Proof . . . Automatic Recovery
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SAVE SPACE, WEIGHT and WIRING

ERA's new high current transistorized Transpacs are miniaturized self-contained AC operated units which provide regulated DC outputs at all standard battery voltages. These units may be used to replace battery sources for laboratory and test purposes or wired into equipment to supply a rugged reliable source of DC power for miniature or standard size electronic devices.

SPECIFICATIONS

Input 105-125 VAC, 60-400cps. Line or load regulation better than 0.05% or 5 millivolts. Ripple less than 1 millivolt. Models listed are specified for operating temperatures up to 55°C. but may be derated for extended temperatures. Extremely high temperature and military designs also available on order. Units include provision for 5% minimum voltage adjustment.

Model No.	Output Volts	Current Amps.	Case Size (WxDxH — inches)	Net Price*
TR6R	6	0-2	4¾ x 4 x 5⅞	$160.
TR12R	12	0-2	4¾ x 4 x 5⅞	160.
TR18R	18	0-2	5 x 4¼ x 6¾	160.
TR24R	24	0-2	5 x 4¼ x 6¾	160.
TR32R	32	0-2	5 x 4¼ x 6¾	160.
TR6-32R	6-32**	0-2	5 x 4¼ x 6¾	185.

* Prices FOB Cedar Grove, subject to change without notice

** Selectable voltages at 6, 12, 18, 24 or 32 VDC

In addition to models listed, units can be supplied to meet special military or commercial requirements. Write for quotations on special types.

For further details send for catalogue #118.

ELECTRONIC RESEARCH ASSOCIATES, INC.
67 Factory Pl., Cedar Grove, N. J. • CEnter 9-3000 • TWX NJ1144
SUBSIDIARIES
Era Electric Corp. • Era Pacific Inc. • Era Dynamics Corporation • Advanced Acoustics Corp.

See these Products at the 1960 I. R. E. Convention Booth No. 2818-2820

Meetings with Exhibits

● As a service both to Members and the industry, we will endeavor to record in this column each month those meetings of IRE, its sections and professional groups which include exhibits.

△

March 21-24, 1960

IRE 1960 International Convention and Engineering Show, Waldorf-Astoria Hotel and New York Coliseum, New York, N.Y.

Exhibits: Mr. William C. Copp, Institute of Radio Engineers, 72 West 45th St., New York 36, N.Y.

April 3-8, 1960

Sixth Nuclear Congress, New York Coliseum, New York, N.Y.

Exhibits: Mr. F. M. Howell, c/o EJC, 29 W. 39th St., New York 18, N.Y.

April 20-22, 1960

SWIRECO, Southwestern IRE Regional Conference & Electronics Show, Shamrock-Hilton Hotel, Houston, Texas.

Exhibits: Mr. A. D. Seixas, SWIRECO, P.O. Box 22331, Houston, Texas.

May 2-4 1960

National Aeronautical Electronics Conference, Dayton Biltmore Hotel, Dayton, Ohio.

Exhibits: Mr. Edward M. Lisowski, General Precision Lab., Inc., Suite 452, 333 West First St., Dayton 2, Ohio.

May 2-6, 1960

Western Joint Computer Conference, Fairmont Hotel, San Francisco, Calif.

Exhibits: Mr. H. K. Farrar, Pacific Tel. & Tel. Co., 140 New Montgomery St., San Francisco 5, Calif.

May 24-26, 1960

Seventh Regional Technical Conference & Trade Show, Olympic Hotel, Seattle, Wash.

Exhibits: Mr. Rush Drake, 1806 Bush Place, Seattle 44, Wash.

May 24-26, 1960

Armed Forces Communications & Electronics Association Convention and Exhibit, Sheraton-Park Hotel, Washington, D.C.

Exhibits: Mr. William C. Copp, 72 West 45th St., New York 36, N.Y.

June 20-21, 1960

Chicago Spring Conference on Broadcast and Television Receivers, Graemere Hotel, Chicago, Ill.

Exhibits: Mr. Stanley Hopper, Zenith Radio Corp., 6001 W. Dickens Ave., Chicago 39, Ill.

June 27-29, 1960

National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D.C.

Exhibits: Mr. L. David Whitelock, BuShips, Electronics Div., Dept. of Navy, Washington, D.C.

(Continued on page 10A)

KAY *Ligna-Sweep®* SKV

SWEEPING OSCILLATOR

Cat. No. 935-A

AUDIO—VIDEO—VHF . . . IN ONE INSTRUMENT!

- **FREQUENCY RANGE—200 CPS TO 230 MC.**
- **SWEEP REPETITION RATES FROM 0.2 TO 60 CPS.**
- **LINEAR AND LOGARITHMIC SWEEPS.**
- **AUDIO SWEEP—200 CPS TO 20,000 CPS.**

- **3 Highly Stable Video Bands—1 kc to 12 mc., Variable or in Single Sweep.**
- **RF Output of 1 Volt RMS at 70 Ohms ±.5 db Over Widest Sweep Width.**
- **8 Narrow Customer Selected Fixed Frequency Bands—20 kc to 12 mc.**
- **9 Fundamental Frequency, Wide VHF Bands—10 mc to 220 mc.**

SPECIFICATIONS

VARIABLE FREQUENCY RANGES: .5-12 mc, .1-12 mc, 10 kc-12 mc, 10-220 mc (9 bands)

FIXED FREQUENCIES: Up to max. of 8 center frequencies (20 kc to 12 mc—Customer selected)

AUDIO RANGE: 200 cps to 20 kc.

SWEEP WIDTHS: Selected for maximum stability 1-10 mc on .5-12 mc band; .2-2 mc on .1-12 mc band; 20-200 kc on 10 kc-12 mc band; 6% to 60% of center freq. to 50 mc and 3 mc to 30 mc above 50 mc on 10-220 mc bands. 2-20 kc on fixed frequencies and audio range.

OUTPUT LEVEL: Continuously variable from 1 volt rms down to 65 db below 1 volt, ±5% over widest sweep. AGC. Audio range: variable .5-1 volt rms.

IMPEDANCE: 70 ohms nominal (50 ohms on request). Audio range: 600 ohms.

SWEEP OUTPUT and REPETITION RATES: Sawtooth for horizontal deflection of oscilloscope. Approx. 7 volts peak to peak—Output Impedance 1000 ohms nom.; fixed 60 cps, line locked; fixed 30 cps. logarithmic (for audio and video application) 3 cont. var. ranges—.2-1 cps, 1-5 cps, 5-30 cps.

MARKERS: Swept signal available for operation of *Vari-Marker* SKV Generator.

Optional Internal Markers. Limited number of sharp, crystal-controlled pulse-type markers at customer specified frequencies can be provided. Please inquire before ordering.

POWER SUPPLY: Input approx. 220 Watts, 117v (±10%), 50-60 cps. B+ electronic regulation.

PRICE: $995.00 f.o.b. factory. Fixed freq. bands add $17.00 per band.

The wide range of frequency and repetition rate in the *Linga-Sweep Model SKV* make it ideally suited for alignment and testing of a wide variety of electronic instruments—audio amplifiers, filters, communication receivers, radar IF channels, TV receivers and transmitters.

The unit is stable and carefully shielded and filiered to prevent spurious signals on beat frequency video bands. A wide range of sweep repetition rates makes viewing easy on conventional oscilloscopes. Low repetition rates used with long persistence screens permit study of high Q circuitry, LF limits of band circuits and observation of the "ring" characteristics of tuned circuits.

Ligna-Sweep® MODEL CP

SWEEPING OSCILLATORS

Cat. No. 932-A: Variable bands between 100 kc and 215 mc. Price: $750.00 f.o.b. factory, 18 pulse-type markers avail. at customer specified freq., $17.00 each.

Cat. No. 932-B: Continuous coverage from 100 kc—150 mc. Price: $750.00 f.o.b. factory. 18 pulse-type markers avail. at customer specified freq., $17.00 each.

SEE UT AT THE IRE SHOW
BOOTHS #3512, 14, 16, 18

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KAY ELECTRIC COMPANY

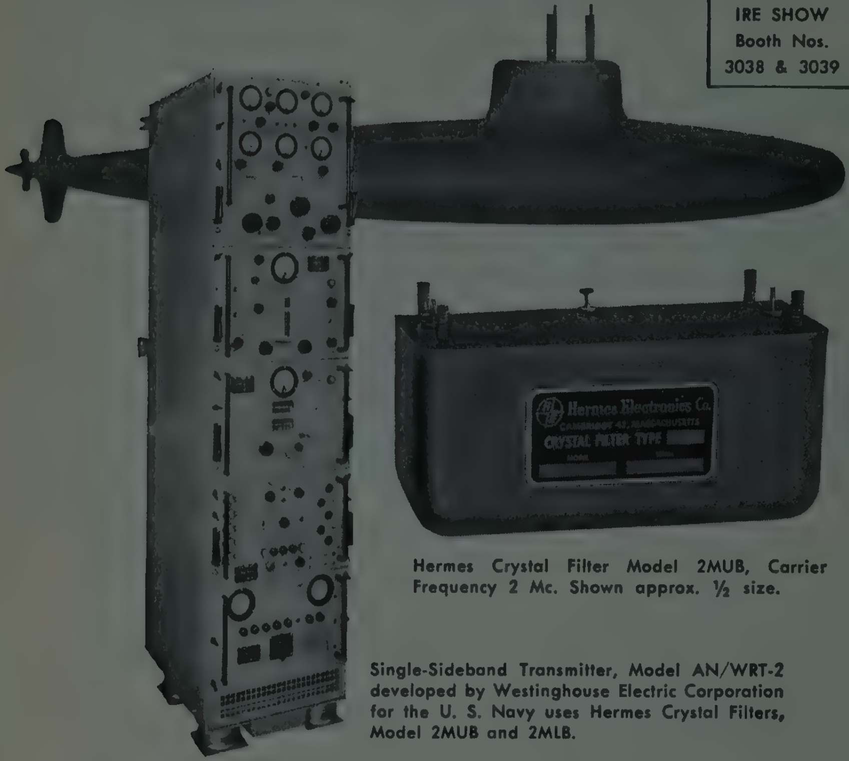
DEPT. I-3, MAPLE AVENUE, PINE BROOK, N. J. CApitol 6-4000

FIRST Navy Militarized SSB Transmitter

Generates Cleaner Signal Using

HERMES CRYSTAL FILTERS

IRE SHOW
Booth Nos.
3038 & 3039



Hermes Crystal Filter Model 2MUB, Carrier Frequency 2 Mc. Shown approx. ½ size.

Single-Sideband Transmitter, Model AN/WRT-2 developed by Westinghouse Electric Corporation for the U. S. Navy uses Hermes Crystal Filters, Model 2MUB and 2MLB.

Recently installed on the atomic submarine SKIPJACK (SSN585), the Westinghouse Electric AN/WRT-2 SSB Transmitter is now standard Navy equipment.

Single sideband signals are generated in the AN/WRT-2 by the selective filter method employing Hermes 2MUB and 2MLB Crystal Filters. These 2.0 Mc Crystal Filters not only offer all the basic advantages of the filter SSB generation method, but reduce the number of heterodyning stages required to translate the modulated signal to the required output frequency. The attendant decrease in unwanted signal generation results in a cleaner signal. The AN/WRT-2 is also a more reliable transmitter because fewer components are used.

In addition to the 2.0 Mc Crystal Filters, Hermes has also supplied SSB units at 87 Kc, 100 Kc, 137 Kc, 1.4 Mc, 1.75 Mc, 3.2 Mc, 6 Mc, 8 Mc, 10 Mc and 16 Mc. These Crystal Filters are presently installed in airborne HF, mobile VHF and point to point UHF SSB systems.

Whether your selectivity problems are in transmission or reception, AM or FM, mobile or fixed equipment, you can call on Hermes engineering specialists to assist in the design of circuitry and the selection of filter characteristics best suited to your needs. Write for Crystal Filter Short Form Catalog.

A limited number of opportunities are available to experienced circuit designers. Send résumé to Dr. D. I. Kosowsky.

Hermes
ELECTRONICS CO.
75 CAMBRIDGE PARKWAY, CAMBRIDGE 42, MASSACHUSETTS

Meetings with Exhibits

(Continued from page 8A)

August 23-26, 1960

WESCON, Western Electronic Show and Convention, Ambassador Hotel & Memorial Sports Arena, Los Angeles, Calif.

Exhibits: Mr. Don Larson, WESCON, 1435 LaCienega Blvd., Los Angeles, Calif.

September 19-21, 1960

National Symposium on Space Electronics & Telemetry, Shoreham Hotel, Washington, D.C.

Exhibits: John Leslie Whitlock Associates, 6044 Ninth St., North, Arlington 5, Va.

October 3-5, 1960

Sixth National Communications Symposium, Hotel Utica & Utica Municipal Auditorium, Utica, N.Y.

Exhibits: Mr. R. E. Bischoff, 19 Westminster Road, Utica, N.Y.

October 10-12, 1960

National Electronics Conference, Hotel Sherman, Chicago, Ill.

Exhibits: Mr. Arthur H. Streich, National Electronics Conference, 184 E. Randolph St., Chicago, Ill.

October 24-26, 1960

East Coast Aeronautical & Navigational Electronics Conference, Lord Baltimore Hotel & 7th Regiment Armory, Baltimore, Md.

Exhibits: Mr. R. L. Pigeon, Westinghouse Electric Corp., Air Arm Div., P.O. Box 746, Baltimore, Md.

Oct. 31-Nov. 2, 1960

13th Annual Conference on Electrical Techniques in Medicine & Biology, Sheraton-Park Hotel, Washington, D.C.

Exhibits: Mr. Lewis Winner, 152 West 42nd St., New York 36, N.Y.

November 14-16, 1960

Mid-America Electronics Convention (MAECON), Municipal Auditorium, Kansas City, Mo.

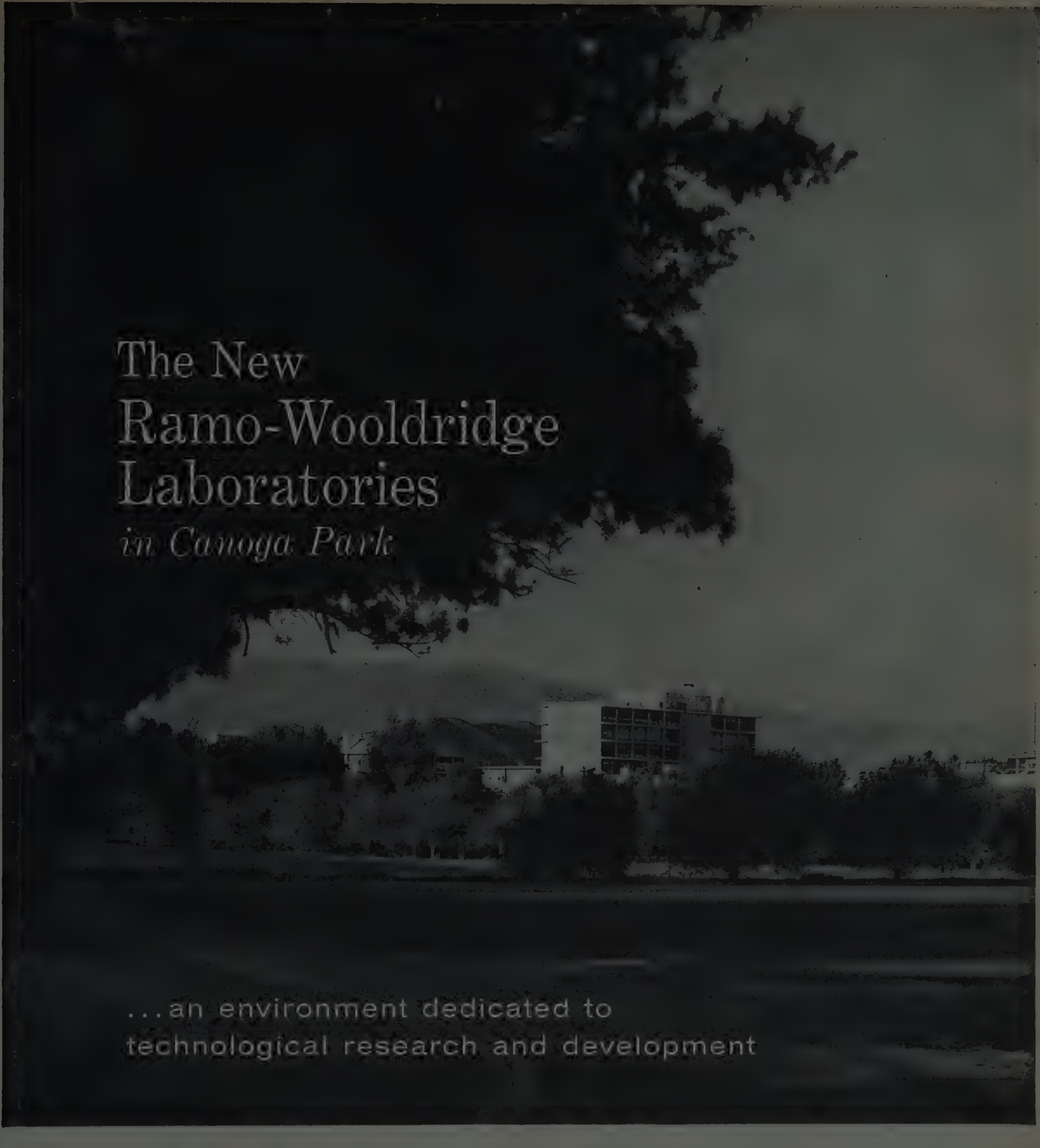
Exhibits: Mr. John V. Parks, Bendix Aviation Corp., P.O. Box 1159, Kansas City 41, Mo.

November 15-17, 1960

Northeast Electronics Research & Engineering Meeting (NEREM), Boston Commonwealth Armory, Boston, Mass.

Exhibits: Miss Shirley Whitcher, IRE Boston Office, 73 Tremont St., Boston, Mass.

Note on Professional Group Meetings: Some of the Professional Groups conduct meetings at which there are exhibits. Working committeemen on these groups are asked to send advance data to this column for publicity information. You may address these notices to the Advertising Department and of course listings are free to IRE Professional Groups.


The New
Ramo-Wooldridge
Laboratories
in Canoga Park
...an environment dedicated to
technological research and development

The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES
8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

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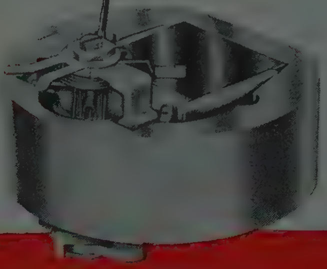
Quality...
First to last

COMPLETE PANEL METE



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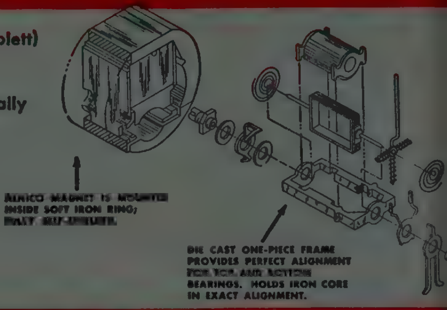
- Self Shielded
- Not affected by magnetic panels or substantially by stray magnetic fields.
- More Torque
- Lower Terminal Resistance
- Faster Response
- Exceedingly Rugged and Accurate
- All Case Sizes


ALNICO MAGNET IS MOUNTED INSIDE SOFT IRON RING; FULLY SELF-SHIELDED.
DIE CAST ONE-PIECE FRAME PROVIDES PERFECT ALIGNMENT FOR TOP AND BOTTOM BEARINGS. HOLDS IRON CORE IN EXACT ALIGNMENT.

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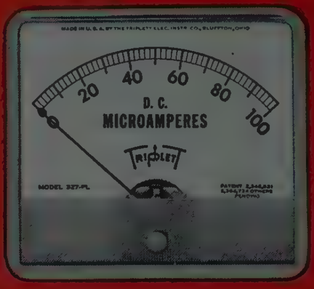
TRIPLETT

Round Flush Mounting (2¹¹⁄₁₆")
Model: DC 221-T, AC 231-S, RF 241-T


D. C. MICROAMPERES
TRIPLETT
MODEL 327-PL

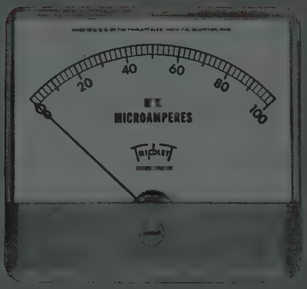
Rectangular Flush Mounting (3⅜")
Model: DC 327-PL, AC 337-PL,
RF 347-PL

D.C. MILLIAMPERES
TRIPLETT

Round Flush Mounting (3½")
Model: DC 321-T, AC 331-S, RF 341-T,
Dyn. 361

D.C. MILLIAMPERES
TRIPLETT

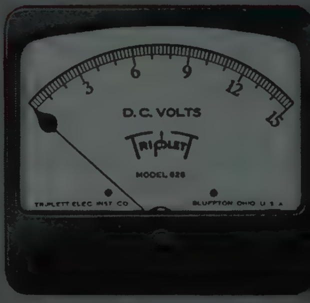
Rectangular Flush Mounting (2⅝")
Model DC 227-T, AC 237-S, RF 247-T


MICROAMPERES
TRIPLETT

Rectangular Flush Mounting (4⅝")
Model: DC 420-PL, AC 430-PL,
RF 440-PL

D. C. MILLIAMPERES
TRIPLETT
MODEL 327-PL

Rectangular Flush Mounting (2¹⁹⁄₃₂")
Model: DC 227-PL, AC 237-PL,
RF 247-PL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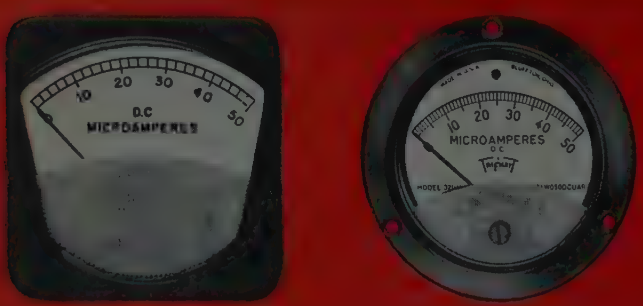
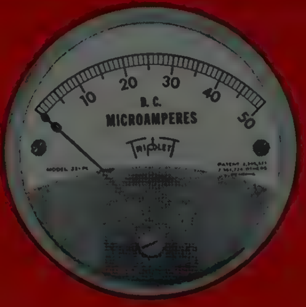
TRIPLETT
MODEL 626
TRIPLETT ELEC INST CO
BLUFFTON OHIO U S A

Rectangular Flush Mounting (6")
Model: DC 626, AC 636, RF 646


D.C. MICROAMPERES
MICROAMPERES D.C.
TRIPLETT

Ruggedized Instruments— 1½", 2½" and 3½"
In addition to the popular commercial line of panel instruments, Triplett supplies a complete line of ruggedized and sealed instruments designed to meet government specification MIL-M-10304A.


D. C. MICROAMPERES
TRIPLETT

Round Flush Mounting (2¹¹⁄₁₆")
Model: DC 221-PL, AC 231-PL,
RF 241-PL

D.C. VOLTS
TRIPLETT

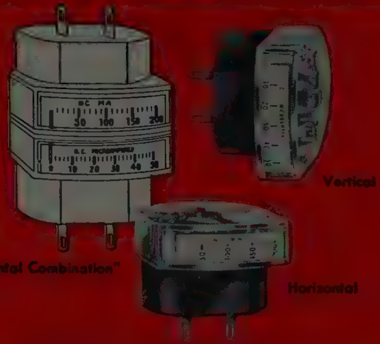
Rectangular Flush Mounting (3")
Model: DC 327-T, AC,337-S, RF 347-T,
Dyn. 367-A

For complete details see your Electronic Parts Distributor, or write

INE FULLY MEETS YOUR NEEDS

The name TRIPLETT has been on instruments of our manufacture for more than 55 years, and is regarded as a symbol of customer satisfaction to industrials and distributors in all parts of the world. Our instruments can be built to customer specifications or provided from our large stocks of standard ranges in hundreds of sizes and types. We also carry in stock many semi-finished movements which can be converted readily to special customer needs.

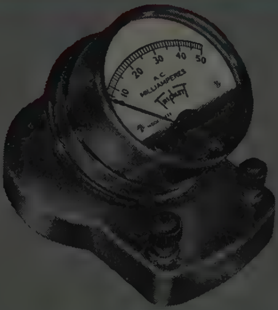
Rectangular Flush Mounting (4½")
Model: DC 420, AC 430, RF 440



Miniature Edgewise Panel Meters —Model 120

Model 327-U Unimeter 3½" Assembled

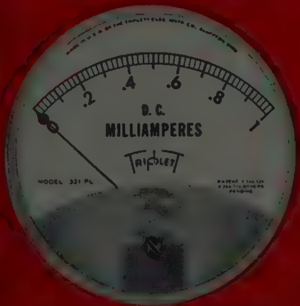
Model 354 Relay



Tilting Case Portable
Model: 325 (DC), 335 (AC)

Model 420-U Unimeter 4½"
with mirror scale

Model 234 Unimeter Stand



Round Flush Mounting (3½")
Model: DC 321-PL, AC 331-PL, RF 341-PL

Rectangular Flush Mounting (7 11/32")
Model: DC 726, AC 736, RF 746

Model 420 VU Meter
Type A Scale

6" Molded Case 4.7" Scale Portables
Model: 625 (DC), 635 (AC).

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IRE News and Radio Notes

CURRENT IRE STATISTICS

(As of January 31, 1960)

Membership—79,514
Sections*—105
Subsections*—27
Professional Groups*—28
Professional Group Chapters—261
Student Branches†—184

* See this issue for a list.
† See October, 1959 issue for a list.

Calendar of Coming Events and Authors' Deadlines*

1960

IRE National Conv., N. Y. Coliseum and Waldorf-Astoria Hotel, New York, N. Y., Mar. 21–24.

First Natl. Symp. on Human Factors in Electronics, BTL Aud., New York, N. Y., Mar. 24–25.

Scintillation Counter Symp., Washington, D.C., Mar.

6th Nuclear Congress, N. Y. Coliseum. New York, N. Y., Apr. 4–8.

14th Spring Tech. Conf., Cincinnati, Ohio, Apr. 12–13.

Conf. on Automatic Tech., Sheraton-Cleveland Hotel, Cleveland, Ohio, Apr. 18–19.

Int'l Symp. on Active Networks and Feedback Systems, Engrg. Soc. Bldg. Auditorium, New York, N. Y., Apr. 19–21.

Int'l Symp. on Active Networks and Feedback Systems, Polytechnic Inst. of Brooklyn, Brooklyn, N. Y., Apr. 19–21.

1960 SWIRECO (Southwestern IRE Regional Conf. and Electronics Show), simultaneously with the Nat'l. PGME Conf., Houston, Texas, Apr. 20–22.

Natl. Aeronautical Electronics Conf., Biltmore and Miami-Pick Hotels, Dayton, Ohio, May 2–4.

URSI-IRE Spring Mtg., Sheraton Park Hotel and NBS, Washington, D. C., May 2–5.

Western Joint Computer Conf., San Francisco, Calif., May 2–6.

PGMTT Natl. Symp., San Diego, Calif., May 9–11.

Electronic Components Conf., Hotel Washington, Washington, D. C., May 10–12.

7th Reg. Tech. Conf. & Trade Show, Olympic Hotel, Seattle, Wash., May 24–26.

6th Radar Symp., Ann Arbor, Mich., June 1–3.

Conf. on Standards and Electronic Measurements, NBS Boulder Labs., Boulder, Colo., June 22–24.

* DL=Deadline for submitting abstracts.

(Continued on page 15A)

CHICAGO SPRING CONFERENCE TO BE HELD IN JUNE

The Chicago Spring Conference (C.S.C.) on Broadcast and Television Receivers will be held for the first time at the Grasmere Hotel on June 20 and 21, 1960. Sponsors are the Professional Group on Broadcast and Television Receivers and the Chicago Section of the IRE.

For the most part the C.S.C. will concern itself with entertainment consumer fields. It will also continue the television aspect of the Spring Technical Conference in Cincinnati, and will run concurrently with the June Furniture Show.

Technical papers on Broadcast and Television Receivers and related fields are requested. Further information may be obtained by contacting Pieter Fockens, C.S.C. Chairman, Zenith Radio Corp., 6001 W. Dickens, Chicago 39, Ill.; Jack E. Bridges, C.S.C. Papers Chairman, Warwick Manufacturing Co., 7300 N. Lehigh, Chicago, Ill.; William G. Henke, C.S.C. Publicity Chairman, Admiral Corp., 3800 Cortland Ave., Chicago 47, Ill.; or Stanley Hopper, C.S.C. Exhibits Chairman, Zenith Radio Corp., 6001 W. Dickens, Chicago 39, Ill.

PGHFE WILL HOLD ANNUAL SYMPOSIUM

The Professional Group on Human Factors in Electronics (PGHFE) will hold its First Annual Symposium on Human Factors in Electronics in New York, N. Y. in the auditorium of Bell Telephone Laboratories, 463 West St. (use Bethune Street entrance), on the evening of March 24 from 7:30 P.M. to 10:00 P.M. and all day on March 25 from 9:30 A.M. to 5:30 P.M.

On the evening of March 24 there will be a symposium on the topic: "Human Factors in Electronics—a Progress Report from Industry." A selected panel of speakers from various industrial organizations will consider the questions:

1) How and to what extent is industry using human factors engineering?
2) What can the PGHFE do to support the work of human factors engineers in the electronic and related industries?

On March 25 a series of papers will be presented on topics such as: Theory of Man-Machine Systems, Effect of Environment on Human Operation of Electronic Equipment, Evaluation of Human Factors Design of Systems, and so forth.

Registration fees are $2.00 per person for IRE members and $3.00 per person for nonmembers. Attendance is limited; advance registration is recommended. Application forms may be obtained from:

K. G. Van Wynen, Chairman
Local Arrangements Committee
Bell Telephone Laboratories,
Room 628A
463 West Street
New York, N. Y.

COMPUTER FEDERATION FORMED BY ELEVEN NATIONS

Computers and information processing assumed global importance in January with the birth of a new international body dedicated to this fast-growing technology. Eleven nations have ratified the statutes of the International Federation of Information Processing Societies, which for the first time will provide a common meeting ground for computer experts from all over the world. Until now, many countries, including the United States, have had their own professional computer societies, but these groups have had no permanent, formal means of meeting and exchanging ideas. The need for better communication in the field of information processing is becoming increasingly important as all nations come to appreciate the vital role computers play in man's daily life.

The movement to form the new Federation was a direct result of the first International Conference on Information Processing, sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and held in Paris last June. As a result a provisional bureau for the International Federation was established, with Isaac L. Auerbach, president of Auerbach Electronics Corp., Narberth, Pa., named provisional chairman. Mr. Auerbach represents the National Joint Computer Committee of the U. S. and was U. S. consultant to UNESCO for the Paris conference. Also named to the provisional committee were Professor A. A. Dorodnicyn, of the U.S.S.R., and A. van Wijngaarden, of The Netherlands, vice-chairmen, and J. A. Mussard, of UNESCO, secretary.

The countries whose national computer technical societies have ratified the statutes include Canada, Denmark, Finland, France, Germany, The Netherlands, Spain, Sweden, Switzerland, the United Kingdom, and the United States. In addition, Belgium, Israel, and Japan are forming national computer societies to qualify for membership.

It is expected that the first meeting of the IFIPS council later this year will result in plans for a second International Conference on Information Processing with an associated technical exhibit in 1963.

Membership in the IFIPS now includes: Computing and Data Processing Society of Canada (Canada), Danish Academy of Technical Sciences (Denmark), Finnish National Committee for Information Processing (Finland), Association Française de Calcul (France), Deutsche Arbeitsgemeinschaft für Rechen-Anlagen (West Germany), Nederlands Rekenmachine Genootschap (Netherlands), Instituto de Electricidad y Automatica (Spain), Swedish Society for Information Processing (Sweden), Swiss Federation of Automatic Control (Switzerland), British Computer Society (United Kingdom), and the National Joint Computer Committee (U.S.A.).

The National Joint Computer Committee comprises representatives of the Institute of Radio Engineers, the Association for Computing Machinery, and the American Institute of Electrical Engineers.

International Congress to Be Held in Rome

The "VIIa Rassegna Internazionale Elettronica Nucleare e della Cinematografia" will be held at the Palazzo dei Congressi, Rome, Italy, from June 15 to 29, 1960, and will include an International Technological Exhibition where all the newest and most interesting projects in the fields of Electronics, Nuclear Energy and Cinematography are being shown; and International Scientific Congresses in which Scientists from the world over take part by submitting papers and/or giving lectures. National official delegations will also be present.

The Scientific Congresses and the Exhibition are both organized to represent a yearly synthesis of the progress internationally achieved in the above-mentioned fields.

The Provisional Programs of the Scientific Congresses are the following:

Electronics

1) Modern amplifiers (parametric and molecular amplifiers).
2) Spatial radiocommunications.
3) Problems connected with broadcasting on bands IV and V.
4) Electronic computers. Collation and processing of data for research operation.
5) General survey of progress in electronics.

Cinematography

a) Long range cinematography and photography.
b) Influence of shooting and screening sizes on the development of cinematography.

Nuclear Energy

Still to be completed.

The Proceedings of the Scientific Congresses of 1959 will be released shortly.

A monograph in five languages by the title of "L'Industria Nucleare Italiana" has been edited by the "Rassegna" in collaboration with the Ministry and the Institute for Foreign Trade, where all Italian Nuclear Industries are listed together with an illustrated presentation of their products. This Monograph may be obtained at the price of Italian Lira 2000 per copy from the "Segreteria Rassegna Internazionale Elettronica Nucleare e della Cinematografia, Via della Scrofa 14, Roma."

Long Island Section To Honor New Fellows

The Long Island Section of the IRE will honor the newly elected Fellows of this section and also newly elected overseas Fellows at a Fellow award presentation on Sunday, March 20, at 4:30 P.M. in the Garden City Hotel, Garden City, N. Y.

The newly elected Fellows from the Long Island Section are Dr. C. E. Dean, Dr. R. K. Hellmann, Prof. W. A. Lynch, D. S. Rau, and W. E. Tolles. A reception for members and guests will follow.

Army MARS Net Appoints Associate Directors

J. P. Hoffman, Information Officer and Frederic H. Dickson, Chief of the Radio Propagation Agency of the U. S. Army Signal Corps at Ft. Monmouth, have been appointed associate net directors of the First U. S. Army MARS SSB Technical Net.

Mr. Hoffman and Mr. Dickson will make arrangements for originating one speaker each month from among the Electronic Scientists and Engineers at Ft. Monmouth.

The net can be heard each Wednesday evening at 9 P.M. EST on 4030 kc upper sideband. The schedule for March includes:

March 2	"Transistorized Test Equipment for the Amateur Radio Station," R. W. Gunderson, Editor, Braille Technical Press, New York, N. Y.
March 9	"Fundamental Requirements for Military SSB Receiver Design," D. Kahn, Instructor, Fixed Station Equipment, U. S. Army Signal Corps School, Ft. Monmouth, N. J.
March 16	"Low Noise Preamplifiers," Dr. J. W. Meyer, Associate Director Division 4, M.I.T. Lincoln Lab., Cambridge, Mass.
March 23	IRE Convention Recess.
March 30	"Fundamentals of Single Sideband and Some Commercial Practice," S. E. Piller, Group Supervisor, Eldico Electronics Div., Radio Engineering Labs., Inc., New York, N. Y.

URSI-IRE Spring Meeting To Be Held in Washington

The URSI-IRE spring meeting will be held at the Sheraton Park Hotel and the National Bureau of Standards, Washington, D. C., May 2–5. The IRE Professional Groups on Antennas and Propagation, Circuit Theory, Information Theory, Instrumentation and Microwave Theory and Techniques are cosponsoring the meeting.

The U. S. National Committee, URSI, will hold a business meeting on Monday morning, May 2. A combined technical session for all participants will be held on Monday afternoon, and the Commissions will hold their business sessions on Monday and Tuesday evenings.

The following Commissions are planning to hold one or more technical sessions in addition to their business meetings:

Commission 1—Radio Measurement Methods and Standards, R. W. Beatty, Chairman.
Commission 2—Tropospheric Radio Propagation, I. H. Gerks, Chairman.
Commission 3—Ionospheric Radio Propagation, L. A. Manning, Chairman.
Commission 4—Radio Noise of Terrestrial Origin, W. Q. Crichlow, Chairman.
Commission 5—Radio Astronomy, E. F. McClain, Chairman.
Commission 6—Radio Waves and Circuits, J. I. Bohnert, Chairman.

Calendar of Coming Events and Authors' Deadlines*

(Continued from page 14A)

Natl. Conv. on Mil. Elec., Sheraton Park Hotel, Washington, D. C., June 27–29.
Cong. Intl. Federation of Automatic Control, Moscow USSR, June 25–July 9.
Int'l Conf. on Electrical Engrg. Education, Sagamore Conf. Center, Syracuse Univ., Syracuse, N. Y., Jul.
WESCON, Los Angeles Mem. Sports Arena, Los Angeles. Calif., Aug. 23–26, (DL*: May 1, R. G. Leitner, WESCON Bus. Office, 1435 So. La Cugna Blvd., Los Angeles 35, Calif.)
URSI 13th Gen. Assembly, Univ. of London, London, Eng., Sept. 5–15.
Joint Automatic Control Conf., M.I.T., Cambridge, Mass., Sept. 7–9.
Space Electronics and Telemetry Conv. and Symp., Shoreham Hotel, Washington, D.C., Sept. 19–22.
Industrial Elec. Symp., Cleveland, Ohio, Sept. 21–22.
Sixth Natl. Communications Symp., Hotel Utica and Utica Municipal Aud., Utica, N. Y., Oct. 3–5. (DL*: June 1, B. H. Baldridge, 25 Bolton Rd., New Hartford, N. Y.)
Natl. Elec. Conf., Hotel Sherman, Chicago, Ill., Oct. 10–12. (DL*: May's 1960 Prof. T. F. Jones, Jr., School of E.E., Purdue Univ., Lafayette, Ind.)
Symp. on Space Navigation, Deshler-Hilton Hotel, Columbus, Ohio, Oct. 19–21.
East Coast Conf. on Aero & Nav. Elec., Baltimore, Md., Oct. 24–26.
5th Ann. Conf. on Nonlinear Magnetics and Magnetic Amplifiers, Oct. 26–28. (DL*: Mar. 15, D. Katz, Bell Tel. Labs., Inc., Whippany, N. J.)
Electron Devices Mtg., Hotel Shoreham, Washington, D. C., Oct. 27–29.
13th Ann. Conf. on Elec. Tech. in Med. and Bio., Sheraton Park Hotel, Washington, D. C., Oct. 31, Nov. 1–2.
Radio Fall Mtg., Hotel Syracuse, Syracuse, N. Y., Oct. 31, Nov. 1–2.
Mid-Amer. Elec. Conv., Kansas City, Mo., Nov. 14–16.
1960 NEREM (Northeast Electronics Res. & Engrg. Mtg.), Boston, Mass., Nov. 15–17.
PGVC Ann. Mtg., Sheraton Hotel, Philadelphia, Pa., Dec. 1–2.
Eastern Joint Computer Conf., New Yorker Hotel, New York, N.Y., Dec.

1961

7th Natl. Symp. on Reliability and Quality Control, Bellevue-Strafford Hotel, Philadelphia, Pa., Jan. 9–11. (DL*: May 9, 1960, R. E. Kuehn, IBM Corp., Owego, N. Y.
IRE National Conv., N.Y. Coliseum and Waldorf-Astoria Hotel, New York, N.Y., Mar. 20–23.
5th Midwest Symp. on Circuit Theory, Univ. of Illinois, Urbana, May 7–8. (DL*: Oct. 1, M. E. Van Valkenberg, Dept. of E.E. Univ. of Ill., Urbana.)
Electronic Computer Conf., West Coast, May 9–11.
WESCON, San Francisco, Calif., Aug. 22–25.

* DL=Deadline for submitting abstracts.

NEC ELECTS 1960 OFFICERS

Dr. Lawrence W. Von Tersch (A'44–M'48–SM'52), head of the electrical engineering department at Michigan State University, has been elected president of the National Electronics Conference for 1960.

Other officers named for the next NEC, which will be held in Chicago at the Hotel Sherman on October 10–12 are:

Executive vice president, Joseph J. Gershon (S'46–M'48–SM'54), DeVry Technical Institute; secretary, James H. Kogen, GPE Controls, Inc.; treasurer, Dr. Harold E. Ellithorn (A'36–M'44–SM'46), University of Notre Dame; assistant Treasurer, Robert J. Parent (M'46), University of Wisconsin.

Dr. Von Tersch, a long-time and active participant in NEC committee work, and formerly vice president of NEC, represents Michigan State University in Conference functions. He is a graduate and received the Ph.D. degree from Iowa State College.

The newly-elected NEC chairman of the board is William O. Swinyard (A'37–M'39–SM'43–F'45), vice-president of Hazeltine Research, Inc. He is a past president of NEC and was a member of the original group responsible for the organization of the Conference.

Committee chairmen elected are:

Arrangements, Benjamin G. Griffith (A'38–VA'39–SM'54), Teletype Corporation; exhibits, John S. Powers (A'44–M'50), Bell and Howell Company; fellowship award, Orville I. Thompson (A'45–M'46–SM'58), DeVry Technical Institute; finance policy, Dr. John D. Ryder (A'29–SM'45–F'52), Michigan State University; housing, Juergen Roedel (S'47–A'50–M'55) Hallicrafters Company; international activities, George E. Anner (A'46–SM'54), University of Illinois; long-range planning, Dr. Christopher E. Barthel, Jr., Armour Research Foundation; NEC party, Stanley I. Cohn (SM'59) Armour Research Foundation; 1959 *Proceedings*, Clyde H. Hoffman (A'54–M'57–SM'59), University of Notre Dame; 1960 *Proceedings*, Dr. Thomas L. Butler, Jr. (A'53–M'58), University of Michigan; program, Dr. Thomas F. Jones, Jr. (SM'48), Purdue University; registration, LeRoy W. Murphy, Illinois Bell Telephone Company; student activities, Dr. M. E. Van Valkenburg (S'43–A'45–SM'53), University of Illinois.

The National Electronics Conference, Inc. is a nonprofit organization serving as a national forum for the presentation of authoritative technical papers on electronic research, development and application. More than 10,000 registrants are expected at the 16th annual NEC, which will be held in Chicago, Ill., in October, 1960.

A few of the activities of NEC include the annual *Fellowship Award* which has a value of $2500 and is designed to assist worthy undergraduates to further their electronic training; the *Annual Award* which honors an author who participated in the program of the preceding year and presented what was considered the finest paper; and the *Award of Merit* which is presented from time to time and honors the author of a particularly influential paper given at any prior Conference. The *Award of Merit* includes a check in the amount of $750. The last such award was presented to engineer-scientist, Dr. Leon N. Brillouin for his paper on "A Theorem of Larmor and Its Importance for Electrons in Magnetic Fields."

A record attendance and number of exhibitors are expected in 1960. Executive and planning committees are studying new programs in preparation for the anticipated future growth of the Conference. Growth has been stimulated by a management consisting of representatives of the four professional societies and nine educational institutions who participate in the Conference. A full-time staff and general manager conduct Conference business activities at NEC headquarters located in Chicago. Requests for information regarding NEC activities and awards should be directed to the Chicago office.

Sponsors include the AIEE, Illinois Institute of Technology, IRE, Northwestern University and the University of Illinois. Participants are Michigan, Michigan State, Notre Dame, Purdue, Wayne State and Wisconsin Universities, EIA, and the Society of Motion Picture and Television Engineers.

ELECTRONICS CONFERENCE ISSUES CALL FOR PAPERS

The National Electronics Conference will be held at the Sherman Hotel, Chicago, Ill., on October 10, 11, and 12, 1960. Authors of papers are invited to submit abstracts of 100 to 150 words (for publication in program) and either a 400 to 500 word summary or the completed paper for review. Submit to Professor Thomas F. Jones, Jr., Program Chairman, NEC, School of Electrical Engineering, Purdue University, Lafayette, Ind.

Technical areas typical of those covered at the Conference include: Adaptive Servomechanisms, Antennas and Propagation, Audio, Circuit Theory, Communication Systems, Computers, Information Theory, Instrumentation and Telemetry, Masers, Microminiaturization, Microwaves, Millimeter Waves, Parametric Amplifiers, Plasma Research, Radar and Radio Navigation, Radio Astronomy, Servomechanisms, Signal-Matched Filters, Solid-State Circuits, Solid-State Devices and Materials, Space Electronics, Communications and Navigation, Television, Transistors, and Value Engineering.

AIR FORCE MARS LISTS MARCH TALKS

The following is the current schedule for the Air Force MARS Eastern Technical Net, which can be heard Sundays from 2 to 4 P.M. EST, at 3295, 7540, and 15,715 kc.

March 6	"The IRE National Convention," G. Bailey, Chairman of the Convention.
March 13	"Sonar Transducers," J. Campani, Chief Engr., Telephonics Corp.
March 20	"Energy Systems for Space Operations," Dr. K. F. Rubert, Scientist, NASA, Langley Field, Va.
March 27	"The Jet Pilot," Flight Lt. H. Clark, RCAF.
April 3	"Tool Design," F. Yesmant, Engr., Riverside Plastics Corp.

DENVER RESEARCH INSTITUTE ANNOUNCES PAPER DEADLINE

The Denver Research Institute of the University of Denver will hold its 7th Annual Symposium on Computers and Data Processing at the Stanley Hotel in Estes Park, Colo., on July 28 and 29, 1960. The continuing theme of this series of meetings has been the advanced treatment of basic problems in computer technology. Papers will be presented in the fields of Components and Devices, Logic Design, and Philosophy of Computer Design.

Although it is anticipated that the program will be comprised largely of invited papers, a limited number will be selected from papers submitted without invitation. Authors wishing to submit papers may send abstracts of approximately 150 words, no later than April 1, 1960, to: W. H. Eichelberger, Denver Research Institute, University of Denver, Denver 10, Colo.

ELECTRONICS MARKETING BUSINESS LETTER SERVICE ESTABLISHED IN NEW YORK

Shepherd's *Electronics Marketing*, a monthly business letter service, was introduced in January, 1960. This publication, plus supplements, presents marketing ideas and information exclusively for the electronics industries. It is published by Shepherd Associates, 130 West 42 St., New York, N. Y., headed by Michael R. Shepherd, publisher, and is edited by Sidney Feldman (A'58), former marketing editor of *Electronic Week*, associate editor of *Forbes Magazine*, and contributor to publications including *The New York Times*, Barron's and others.

The new publication covers electronics markets, as well as marketing management, services and personnel.

WILLOW RUN LABS WILL HOLD 6th ANNUAL RADAR SYMPOSIUM

Since 1955, annual radar symposiums have been held at The University of Michigan, Ann Arbor, in recognition of the fact that the dissemination of information among scientists and engineers working in the field of radar is necessary to improve radar techniques, devices, and applications. Continuing the series, the Radar Laboratory of the Willow Run Laboratories at The University of Michigan will conduct the Sixth Annual Radar Symposium at Ann Arbor on June 1–3, 1960, with the support of Project MICHIGAN and under sponsorship of the Army, Navy, and Air Force. Project MICHIGAN, which engages in research and development for the U. S. Army Combat Surveillance Agency, is carried on by the Willow Run Laboratories under Department of the Army Contract DA-36-039 SC-78801, administered by the U. S. Army Signal Corps.

The tentative program consists of single general sessions each morning and multiple specialized sessions and panel discussions each afternoon. Papers will pertain to the general field of radar, with particular emphasis on these major areas: Components and Techniques, Propagation Phenomena, Engineering Applications, and New Data and Their Organization.

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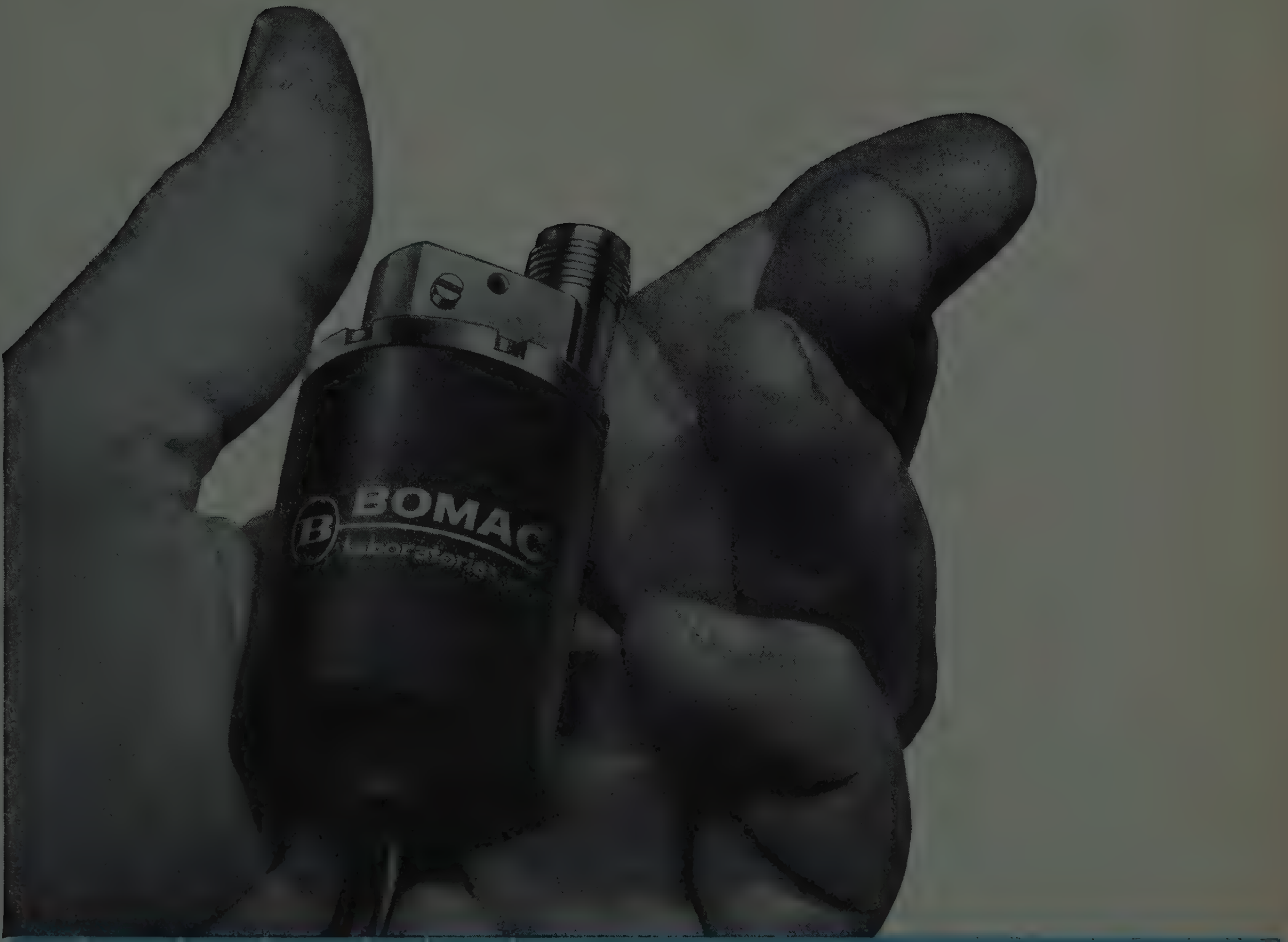

Band	Tube Type	Fixed Freq. or Tunable	Frequency Range Mc	Min. Peak Power Watts	Output Mates With
C	BL-212	Tunable	5400-5900	100	UG699/U
C	BL-243	Tunable	5400-5900	200	UG699/U
C	BL-242	Tunable	5400-5900	400	N
C	BLM-022	Tunable	5400-5900	500	TNC
C	BLM-026	Tunable	5400-4900	500	TNC
C	BLM-020	Tunable	5400-5900	700	TNC
C	BL-245	Tunable	5400-5900	900	TNC
C	BL-250	Tunable	5400-5900	150	TNC
X	BLM-003	Tunable	9000-9500	150	TNC
X	BLM-014	Tunable	8500-9000	150	TNC
X	BLM-012	Tunable	8900-9400	1000	TNC
X	BLM-021	Tunable	8900-9400	1000	UG40A/U
X	BLM-024	Tunable	9300-9500	150	TNC

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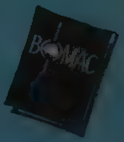

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NAB SELECTS T.A.M. CRAVEN FOR ENGINEERING AWARD

The National Association of Broadcasters has announced that it will present its second annual Engineering Achievement Award to Federal Communications Commissioner T. A. M. Craven (F'29) for his "long and distinguished career" during which he has "measurably advanced the technical state of broadcasting through his long and vigorous leadership in engineering activities."

The award will be presented to him on April 6 at a joint engineering-management luncheon of the NAB's Annual Convention in Chicago.

Commissioner Craven was selected by an Awards Subcommittee of the NAB's Broadcast Engineering Conference Committee.

He has just completed an assignment as chairman of the United States Delegation, Administrative Radio Conference, International Telecommunications Union in Geneva, Switzerland. His career includes participation on most of the principal international conventions on communications. He also was a pioneer in adopting directional antennas to facilitate the growth of broadcasting.

He began a seven-year term on the Federal Communications Commission on June 30, 1956, following appointment by President Eisenhower. He previously had served on the Commission during the Roosevelt administration and was the first commissioner to receive nonconsecutive appointments. His experience in Government regulation of electrical communication began in 1928 when, for about two years, he served on the staff of the Federal Radio Commission in charge of nonbroadcast engineering matters. He first joined the FCC as its Chief Engineer in 1935, which post he held until he became a Commissioner.

Born January 31, 1893 in Philadelphia, Pa., he was graduated from the U. S. Naval Academy in the class of 1913. During his naval career he specialized in radio communication. He served afloat as radio officer of various battleships and as fleet radio officer, first of the U. S. Asiatic Fleet and then the combined U. S. Fleet. He was responsible for the first modernization of the fleet radio communications system and received a special commendation for his World War I development of a means of transmitting orders to ships in submarine-infested waters without disclosing vessel positions.

During his naval and civilian Government career, he has been a member of and at one time chairman of the Interdepartment Radio Advisory Committee. Since 1919, he has been either a technical advisor, a member, or chairman of U. S. delegations to various international radio conferences including the Allied Radio Consulting Committee, Communications Conference of Allied and Associated Powers, Provisional Inter-Allied Radio Technical Consulting Committee, International Radio Conference (for which service he was commended by the Secretary of the Navy), First International Radio Consulting Committee, United States-Canadian Radio Conference, International Radio Conference, Inter-American Radio Conference, and North American Regional Broadcasting Conference.

In 1930 he resigned his commission as a Lieutenant Commander in the regular Navy and from then, until 1944, served as a Commander in the U. S. Naval Reserve.

From 1930 to 1935 he was vice president in charge of technical matters of several broadcasting companies. During that period he also engaged in private practice as a consulting radio engineer. From 1944 to 1949 he was vice president in charge of technical matters for the Cowles Broadcasting Co. At the same time he was a member of the board of directors of the National Association of Broadcasters. In 1949 he became a member of the firm of Craven, Lohnes and Culver, Washington, D. C. He is a past president of the Association of Federal Communications Commission Consulting Engineers.

CINCINNATI CONFERENCE TO BE HELD IN APRIL

The Spring Technical Conference of the Cincinnati Section of the IRE will be held on Tuesday and Wednesday, April 12 and 13, 1960, at the Hotel Alms in Cincinnati, Ohio.

Under the direction of John Ebbeler, the committee has decided to present the Fourteenth Annual Conference in conjunction with the American Rocket Society. The conference themes are electronic data processing and space technology.

The committee members for the conference are J. R. Ebbeler, Conference Chairman; A. B. Ashman, Registration Chairman; R. P. Schlemmer, Advertising Chairman; S. W. Stuhlbarg, Papers Chairman; C. F. Winder, Banquet Chairman; R. H. Lehman, Arrangements Chairman; and V. Scott, Publicity Chairman.

The sessions will be:

I. Venus, Target for Tonight
II. Re-entry
III. Bio-Electronics
IV. Objectives of the IGY
V. Inertial Guidance
VI. Can Machines Outthink People?
VII. Electronic Data Processing Comes of Age
VIII. Why Will Tunnel Diodes Revolutionize Electronics?

OBITUARY

James W. McRae (A'37–F'47), Vice President of AT&T Co. and 1953 President of the IRE, died recently at the age of 49.

J. W. MCRAE

Born on October 25, 1910 in Vancouver, B. C., Canada, Dr. McRae received the B.S.E.E. degree in 1933 from the University of British Columbia. He received the M.S. and Ph.D. degrees from California Institute of Technology in 1934 and 1937, respectively.

Early in 1937 he had joined the Bell Telephone Laboratories, where he engaged in research on transoceanic radio transmitters. After working on microwave research, he worked on military projects, including a special microwave oscillator for the NDRC and early association with several microwave radar projects. After serving in the U. S. Army Signal Corps in World War II, he returned to Bell Labs. to become Director of Radio Projects and Television Research in 1946. In 1947 he became Director of Electronic and Television Research, which made him responsible for electron dynamics research. He was appointed Director of Apparatus Development I in 1949, and later that year he became Director of Transmission Development. In 1951 he was elected a Vice President of the Laboratories, in charge of the Systems Organization, responsible for switching and transmission development and systems engineering. In 1953 he was elected a Vice-President to Western Electric Co. and President of Sandia Corp. In 1958 he was elected Vice President of AT&T, responsible for the defense activities of the Bell System.

In 1958 he was appointed to the General Advisory Committee to the Atomic Energy Commission, and in 1959 he was named Chairman of the Army Scientific Advisory Panel.

Dr. McRae was a member of the Board of Editors of the IRE from 1946 to 1949. He was chairman of the New York Section in 1949, Chairman of the Ad Hoc Committee on Technical Groups, and Chairman of a Committee on Section vs Subsection Problems in 1952. He was a member of the Board of Directors and the Executive Committee from 1949 to 1955. He also served on a number of other Institute committees.

Dr. McRae received honorary mention from Eta Kappa Nu as an outstanding young electrical engineer in 1943, and he received the Legion of Merit for his work in radar during World War II. He was a member of AIEE and Sigma Xi.

1960 Nuclear Congress

NEW YORK COLISEUM, NEW YORK, N. Y., APRIL 4–7, 1960

A partial program of sessions planned for the 1960 Nuclear Congress, to be held in the New York Coliseum, April 4–7, has been announced by Dr. Clarke Williams, chairman of the Nuclear Congress.

The Congress, a gathering of representatives from all areas of the nuclear field, is sponsored by 28 leading engineering, scientific, management, and technical organizations. It consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition.

The Exposition, which was established in 1954, will include at least 130 exhibits of the manifold products and services available for the peaceful use of atomic energy. More than 1000 requests for information regarding participation in the exhibit have been received from firms all over the world.

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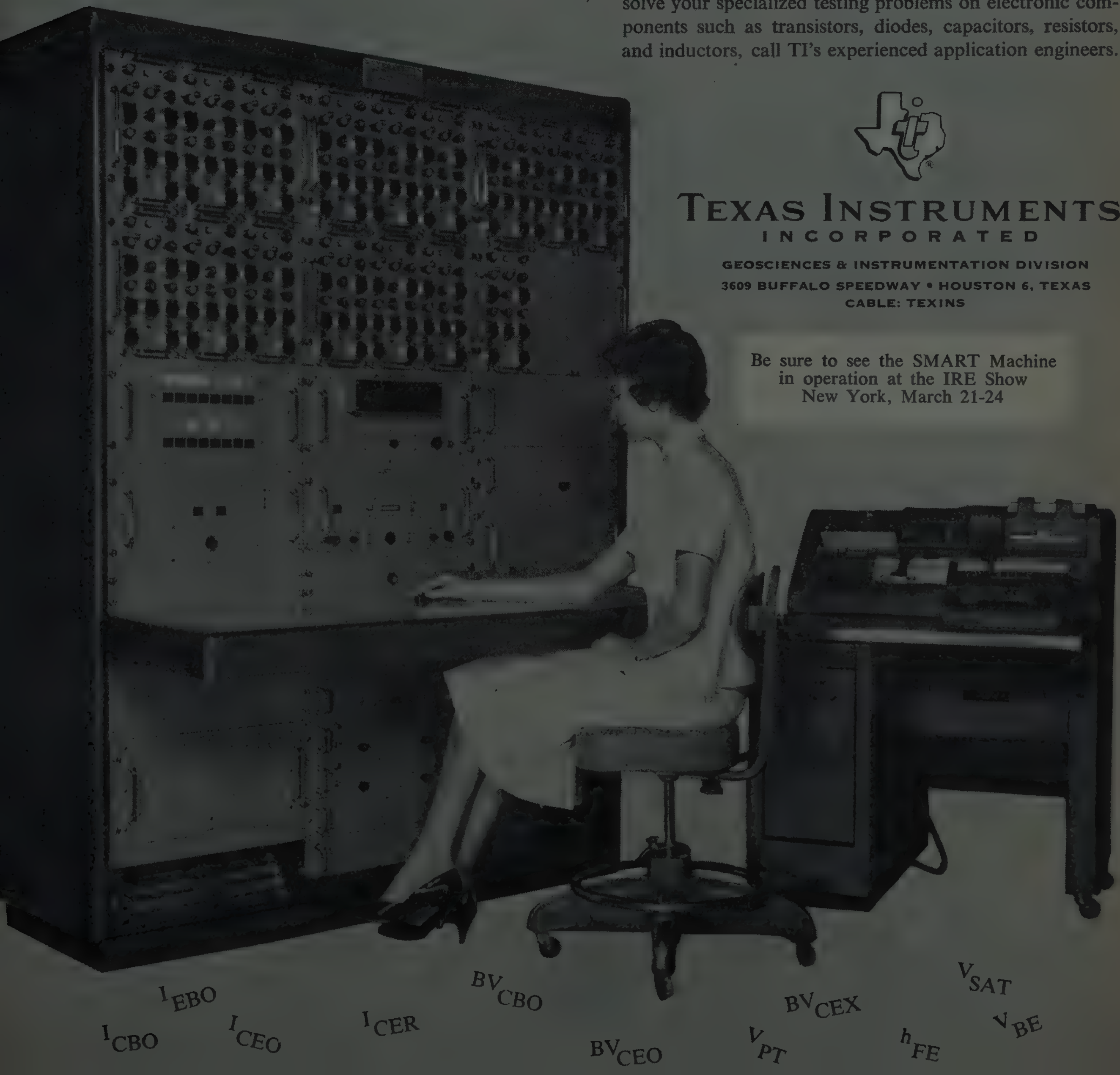

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The Congress sessions are expected to draw the largest audience of engineers and related specialists—as well as the largest representation of industrial and scientific exhibitors—ever to attend an event of this kind.

The estimate of this record-breaking attendance is based on the fact that 35 per cent of the nation's 600,000 engineers live and work within 300 miles of New York, N. Y., and many others have headquarters there.

The theme of the meeting, according to E. B. Gunyou, program committee chairman of the Nuclear Congress, will be "What Will the Future Development of Nuclear Energy Demand from Engineers?" This question will be approached through a series of reports, papers, and discussions on a wide variety of subjects related to the peaceful use of atomic energy.

Environment Session I

Chairman: *J. C. Callahan, Morris Knowles, Inc.*

"Current Cost and Construction Experience at Yankee Reactor Site," *C. T. Chave, Stone & Webster, Boston, Mass.*

"Pressure Suppression," *F. F. Mautz, Pacific Gas & Electric Co., San Francisco, Calif.*

"Pressure Liquidation," *A. F. Kolflat, Sargent & Lundy, Chicago, Ill.*

"Review of Shippingport Operations—Site Factors," *J. E. Gray, Duquesne Light Co., Pittsburgh, Pa.*

"A Progress Report on the N.S. *Savannah*," *P. P. Eddy and K. W. Hess, Nuclear Projects Office, Washington, D. C.*

Environment Session II

Chairman: *M. Eisenbud, New York Univ., New York, N. Y.*

"Local Problems in Regulation," *H. Blatz, New York City Health Dept., New York, N. Y*

"State Food Problems," *L. Menzer, Hartford City Health Dept., Hartford, Conn.*

"Needs for Uniformity in Laws."

"International Problems in Radiation," *Representative of the U. N.*

Environment Session III

Chairmen: *E. S. Cole, Pitometer Assocs., and R. E. Fuhrman, Fed. of Sewage & Indust. Wastes Assoc.*

"Environmental Radioactivity in Large Area Surrounding Nuclear Electric Plant," *J. V. Nehemias, Radiological Health Surveys of National Sanitation Found., Univ. of Michigan, Ann Arbor.*

"Strontium 90 in Surface Waters," *C. P. Straub, L. R. Setter, P. F. Hallbach, Dept. of Health, Education and Welfare, Washington, D. C., and R. A. Taft Engrg. Center, Cincinnati, Ohio.*

"Use of Tritium as a Tracer in Evaluating Waste Discharges," *W. J. Kaufman and R. M. Hours, Univ. of California, Berkeley.*

"Hanford Reactor Effluent Contribution to Environmental Radiation Dose," *R. L. Junkins, General Electric Co., Richland, Wash.*

Materials and Components Session I

Chairman: *B. W. Dunnington, Battelle Memorial Inst., Columbus, Ohio.*

"Effect of Irradiation on Tensile Properties of High-Temperature Steel and Non-Ferrous Alloys," *S. Bartz, Phillips Petroleum Co.*

"Experience in Use of Organic Coolant in Nuclear Reactors," *H. Perlman, Atomics International, Canoga Park, Calif.*

"Problems in Contamination of Water-Cooled Reactors Using Stainless Steel Components," *D. Foley, Alcoa, Inc., Schenectady, N. Y.*

Materials and Components Session II

"Ignition and Detonation of Uranium in Boron Trifluoride Solutions," *R. Johnson, F. Horn and G. Strickland, Brookhaven National Lab., Upton, N. Y.*

"Uranium-Thorium Reprocessing; Cost Outlook for Commercial Operation," *R. J. Klotzbach, Union Carbide Nuclear Co., New York, N. Y.*

"The Plutonium Cycle," *J. J. Cadwell, Hanford Atomic Products Operation, General Electric Co., Richland, Wash.*

"Nuclear Fuel in West Germany," *A. Boettcher, Degussa, Frankfort, Germany.*

"Low Impurity Core Material," *G. Pancer and J. L. Zegger, Alco Products, Schenectady, N. Y.*

Reactor Session I

U. S. Power Reactors

Chairman: *S. Baron or B. Noyes, Burns & Roe, Inc., New York, N. Y.*

"The Army Nuclear Power Program," *Col. D. G. Williams, Chief, Army Nuclear Power Program.*

"BUDOCKS Role in the Development of Nuclear Power for the Navy's Shore Establishments," *Comm. W. J. Christensen, CEC, U. S. Navy.*

Reactor Session II

Research Reactors and Radiation Facilities

Chairman: *H. Neal, American Machine & Foundry.*

"BMI Reactor Operations and Interesting Experiments," *J. Chastane.*

"How to Live with Experimenters Operating Problems with New Reactors," *J. Cox, Oak Ridge National Lab., Oak Ridge, Tenn.*

"McMaster University Reactor Experimental Operations," *Dr. Thod or W. Fleming, McMaster Univ., Hamilton, Ont.*

"BNL Medical Reactor with a Survey of Other Reactor Operating Difficulties and Remedies," *R. Burrell, Brookhaven National Lab., Upton, N. Y.*

Reactor Session III

Progress in Reactor Instrumentation

Chairman: *H. A. Lamonds, North Carolina State College, Raleigh.*

"Application of Control and Instrumentation," *W. Lapinski, Argonne National Lab.*

"Application and Effect of Control and Instrumentation," *C. F. Obermesser, Westinghouse Electric Corp.*

"C. & I Equipment—In-Core," *H. M. Ogle, General Electric Co., San Jose, Calif.*

"C & I Equipment—External," *E. P. Epler, Oak Ridge National Lab., Oak Ridge, Tenn.*

"Significance and Need of C & I," *H. E. Vann, Atomic Energy Commission.*

Reactor Session IV

Advanced Reactor and Fuel Cycles

Chairman: *L. J. Everett, Philadelphia Electric Co., Philadelphia, Pa.*

"Advanced Water Cooled Reactor," *representative of Westinghouse.*

"Army Gas Cooled Reactor Systems Program," *M. A. Rosen and Capt. G. A. Bicher.*

Nuclear Propelled Aircraft Session I

"Some Practical Methods for Fabricating Shields for Nuclear Powered Aircraft," *W. Q. Hullings and J. L. McDaniel, Covair, Fort Worth, Texas.*

"Nuclear Propulsion for Lifting (Large) Space-Stations into Orbit," *Dr. R. A. Mayer, Norair Div. of Northrop Corp., Hawthorne, Calif.*

"Nuclear Ramjet Developments," *T. C. Merkel, Univ. of California, Radiation Lab., Livermore, Calif.*

"The Effect of Gamma Radiation Upon an Electro-Hydraulic Servo System," *R. N. Miller and W. C. Bennett, Lockheed Aircraft Corp., Marietta, Ga.*

Aircraft Nuclear Propulsion Session II

"The Nuclear Propelled Airship," *L. Jurich, Goodyear Aircraft Corp., Akron, Ohio.*

"Potential of Nuclear Powered Aircraft for Commercial Cargo," *J. F. Brady, Jr., Covair, San Diego, Calif.*

"Three Approaches to Achieving Reliability for Nuclear Powered Navy Aircraft," *L. Credit, Nuclear Div., The Martin Co., Baltimore, Md.*

Nuclear Standards Session

Chairman: *F. L. LaQue, International Nickel Co., New York, N.Y.*

N. L. Mochel, Westinghouse Electric Corp., Lester Station, Philadelphia, Pa., will speak for the American Society for Testing Materials, of which he is a past president.

Dr. C. R. McCullough, Atomic Energy Commission, Washington, D. C., who is chairman of the American Nuclear Society Standards Committee, will speak for that group.

E. Bailey, Commonwealth Edison Co., Chicago, Ill., will speak for the American Society of Mechanical Engineers' Special Committee on Nuclear Power of the Boiler and Pressure Vessel Committee.

J. A. Klapper, Ebasco Service Inc., New York, N. Y., will speak for American Standards Association. He is chairman of the Materials Task Force, Nuclear Advancement Committee, of the Standards Association.

Isotope Application Session

"Industrial Radioisotope Applications Development Sponsored by AEC," *P. G. Aebersold, Office of Isotopes Development, United States Atomic Energy Commission, Washington, D. C.*

"Isotopes in Petroleum Production," *M. Williams, Humble Oil & Refining Co., Houston, Texas.*

"Industrial Activities in Applications of Radioisotopes," *P. Kruger, Nuclear Science & Engineering Corp., Pittsburgh, Pa.*

"Isotopic Power," *J. G. Morse, Isotopic Power Dept. The Martin Co., Baltimore, Md.*

"Preparation, Properties and Applications of Radioactive Clathrates," *D. J. Chleck, Tracerlab Inc., Waltham, Mass.*

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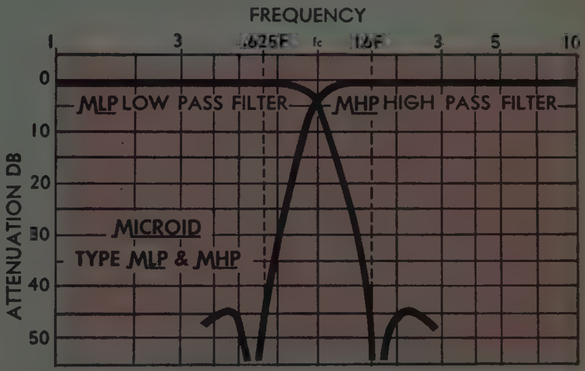

Note: First informal meeting of Club members will be held in Burnell Booths 2909-2910 during the IRE Show, New York Coliseum, March 21-24. See you there.

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Antennas & Propagation (G-3)—A. Dorne, Dorne and Margolin, Westbury, L. I., N. Y.; S. A. Bowhill, Pennsylvania State Univ., University Park, Pa.

Audio (G-1)—Prof. A. B. Bereskin, E.E. Dept., Univ. of Cincinnati, Cincinnati 21, Ohio; M. Camras, Armour Res. Found. Tech. Ctr., Chicago 16, Ill.

Automatic Control (G-23)—J. E. Ward, Servomechanisms Lab., M.I.T., Cambridge 39, Mass.; G. S. Axelby, Westinghouse Air Arm Div., Friendship Airport, Baltimore 3, Md.

Broadcast & Television Receivers (G-8)—R. R. Thalner, Sylvania Home Electronics, 700 Ellicott St., Batavia, N. Y.; C. W. Sall, RCA, Bldg. 13-4, Camden, N. J.

Broadcasting (G-2)—G. E. Hagerty, Westinghouse Elec. Corp., 122 E. 42 St., Suite 2100, N. Y. 17, N. Y.; W. L. Hughes, E.E. Dept., Iowa State College, Ames, Iowa.

Circuit Theory (G-4)—S. Darlington, Bell Telephone Labs., Murray Hill, N. J.; W. Bennett, Bell Telephone Labs., Murray Hill, N. J.

Communications Systems (G-19)—J. E. Schlaikjer, IT&T Co., 67 Broad St., N. Y. 4, N. Y.; M. R. Donaldson, Electronic Comm. Inc., St. Petersburg, Fla.

Component Parts (G-21)—J. J. Drvostep, Sperry Gyroscope Co., Mail Station 1A 36, Great Neck, L. I., N. Y.; G. Shapiro, Engineering Electronics Sec. Div. 1.6, NBS, Connecticut Ave. and Van Ness St., Washington, D. C.

Education (G-25)—J. G. Truxal, Head, Dept. of E.E., Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.; W. R. LePage, Dept. of E.E., Syracuse Univ., Syracuse, N. Y.

Electron Devices (G-15)—W. M. Webster, Semi-Conductor Div., RCA, Somerville, N. J.; E. L. Steele, Hughes Prods., Inc., International Airport Station, Los Angeles 45, Calif.

Electronic Computers (G-16)—R. O. Endres, Rese Engrg. Co., Philadelphia, Pa.; H. E. Tompkins, Moore School of E.E., Univ. of Pennsylvania, Philadelphia, Pa.

Engineering Management (G-14)—H. M. O'Bryan, Sylvania Elec. Prods., 730 3rd Ave., N. Y. 17, N. Y.; A. H. Rubenstein, Northwestern Univ., Evanston, Ill.

Engineering Writing and Speech (G-16)—T. T. Patterson, Jr., RCA, Bldg. 13-2, Camden, N. J.; J. Kinn, Electronics, 330 W. 42 St., N. Y., N. Y.

Human Factors in Electronics (G-28)—C. M. Jansky, Royal McBee Corp., Portchester, N. Y.; J. I. Elkind, Bolt, Beranek and Newman, Cambridge, Mass.

Industrial Electronics (G-13)—J. E. Eiselein, RCA Victor Div., Camden, N. J.; R. W. Bull, Armour Res. Found., Chicago, Ill.

Information Theory (G-12)—P. Elias, M.I.T., Rm. 26-347, Cambridge 39, Mass.; G. A. Deschamps, E.E. Dept., Univ. of Illinois, Urbana, Ill.

Instrumentation (G-9)—C. W. Little, C-Stellerator Assoc., Box 451, Princeton, N. J.; G. B. Hoadley, Dept. of E.E., North Carolina State College, Raleigh, N. C.

Medical Electronics (G-18)—W. E. Tolles, Airborne Instruments Lab., 160 Old Country Rd., Mineola, L. I., N. Y.; L. B. Lusted, Univ. of Rochester Medical School, Strong Memorial Hosp., Rochester 20, N. Y.

Microwave Theory and Techniques (G-17)—A. A. Oliner, Microwave Res. Inst., 55 Johnson St., Brooklyn 1, N. Y.; D. D. King, Electronic Comm., Inc., 1830 York Rd., Timonium, Md.

Military Electronics (G-24)—H. Randall, 1208 Seaton Lane, Falls Church, Va.; D. R. Rhodes, Radiation Lab., Instrument Div., Orlando, Fla.

Nuclear Science (G-5)—A. B. Van Rennes, United Res. Inc., Tech. Div., 128 Alewife Brook Pkwy., Cambridge, Mass.; R. F. Shea, Dig Power Plant Engrg., Knolls Atomic Power Lab., General Electric Co., Schenectady, N. Y.

Production Techniques (G-22)—L. M. Ewing, General Electric Co., HMEED CSP-3, Syracuse 1, N. Y.; A. R. Gray, Rte. #1, Box 940, Orlando Vineland Rd., Wintergarden, Fla.

Radio Frequency Interference (G-27)—J. P. McNaul, U. S. Signal Corps., Hdqrs. Ft. Monmouth, N. J.; P. O. Schreiber, Technical Wire Prods., Springfield, N. J.

Reliability and Quality Control (G-7)—P. K. McElroy, General Radio Co., 22 Baker Ave., West Concord, Mass.; E. J. Breiding, IBM Corp., Kingston, N. Y.

Space Electronics and Telemetry (G-10)—C. H. Hoeppner, Radiation, Inc., Melbourne, Fla.

Ultrasonics Engineering (G-20)—W. Roth, Roth Lab., 1240 Main St., Hartford 3, Conn.; O. Mattiat, Aerophysics Dev. Corp., P.O. Box 689, Santa Barbara, Calif.

Vehicular Communications (G-6)—A. A. MacDonald, Motorola, Inc., 4545 Augusta Blvd., Chicago 51, Ill.; R. P. Gifford, General Electric Co., Syracuse, N. Y.

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* Name listed are Group Chairmen and Transactions Editors.

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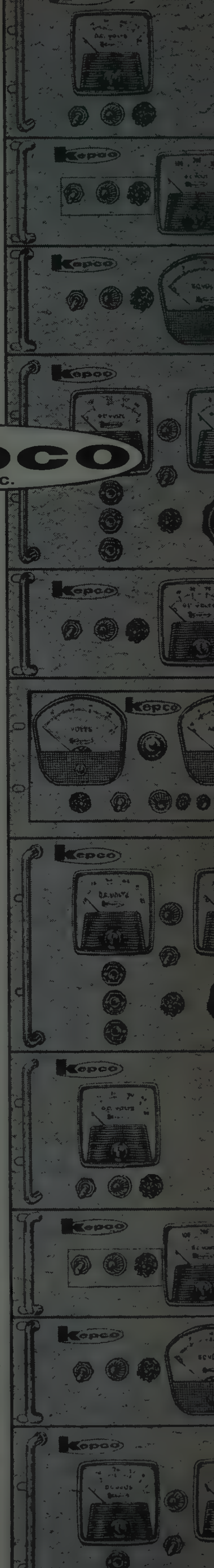

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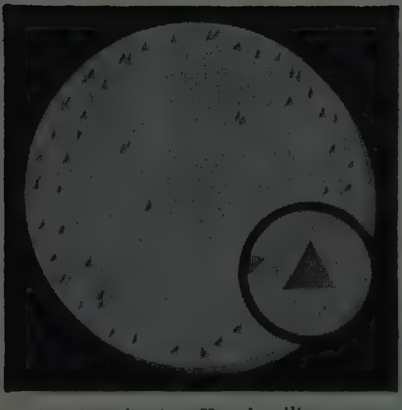

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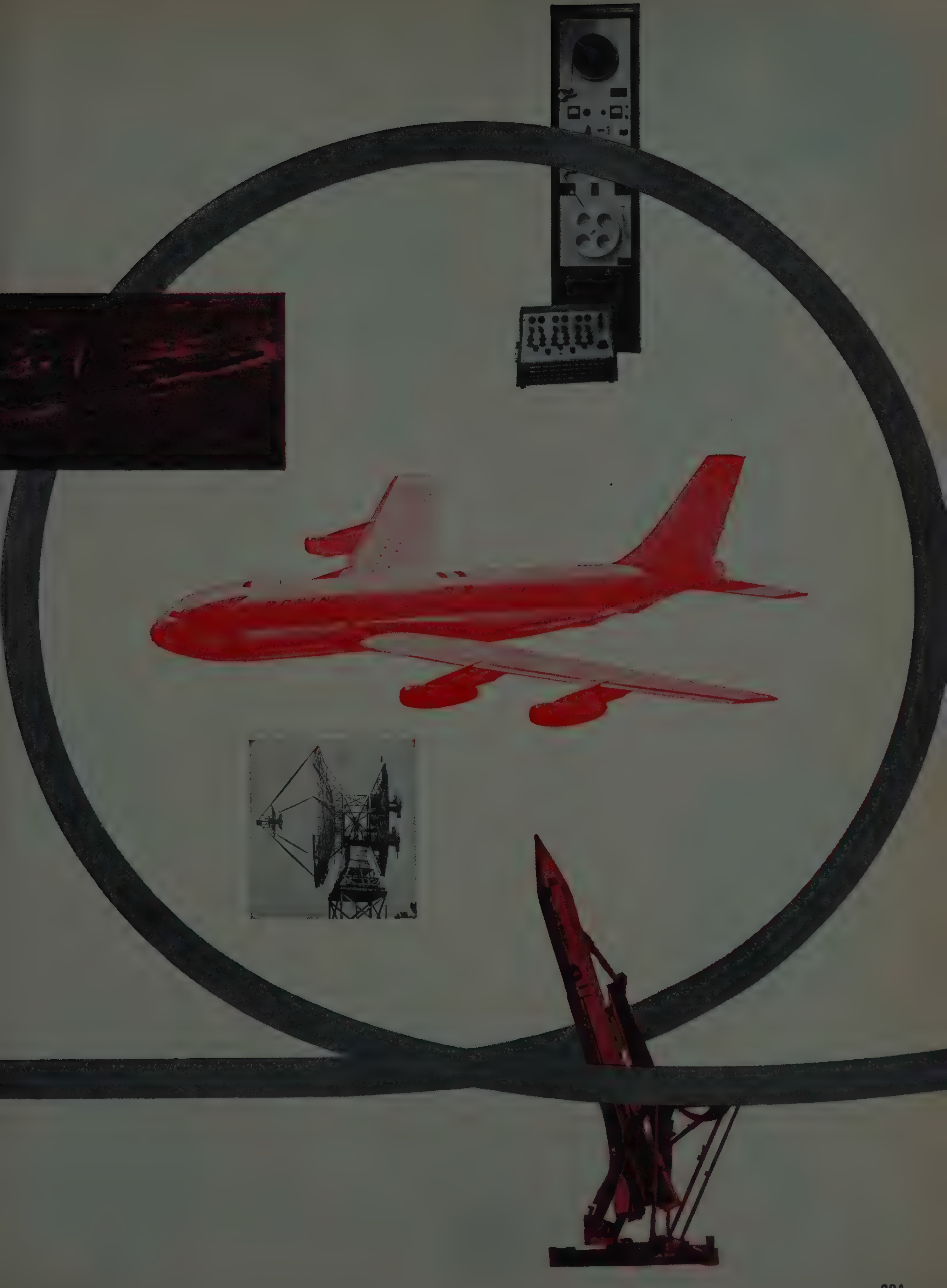

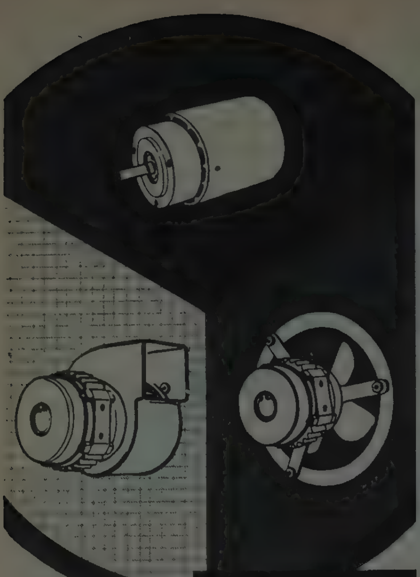

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Lt. Colonel Melvin N. Abramovich (S'36—A'46—M'47—SM'50), USAF, has been recently appointed Chief of the Washington, D. C. Regional Office of the Air Research and Development Command. In this position he will direct the technical liaison activities of that office for Headquarters ARDC and its agencies. The Washington Regional Office is part of a nationwide system of Regional and Liaison Offices established by ARDC to facilitate technical coordination and liaison between Air Force research and developmental agencies and other government, industry, public and private laboratories and institutions engaged in research, engineering, testing and evaluation of technical equipments and systems. Coverage includes work in all fields of science and engineering and in the various technical areas in which the AF research and development program is divided. Three additional Regional Offices are located in New York City, Chicago, and Los Angeles. Each of these offices, in turn, has a number of satellite Liaison Offices located at other geographical centers of engineering activities. The services of all these offices are available to industry to aid them in their dealings with the Air Research and Development Command complex.

M. N. Abramovich

Lt. Colonel Abramovich is a graduate of the Institute of Technology of the University of Minnesota and has received additional training at Massachusetts Institute of Technology and George Washington University. He also attended the Army's Signal Corps School at Fort Monmouth, N. J. He later joined the Curtiss-Wright Corp. In 1940 he was called to active duty and served in various electronic and communications assignments including the Communications Department of the Armored Force School, at Fort Knox, R&D Division of the Office of the Chief Signal Officer, Watson Laboratories (now Rome Air Development Center) and AAF Liaison Office of the Navy's Bureau of Ships, and Headquarters USAF. While overseas during World War II, he served as Deputy Chief Radar Officer of the Mediterranean Allied Coastal Air Force. Upon returning to civilian status, he joined Cambridge Electronics Corporation of Baltimore. In 1947 he was again recalled to active duty to become the technical liaison officer for the Engineering Division of the Air Materiel Command with duty station at the Naval Research Laboratory. He later served in the Electronics Directorate at Headquarters ARDC. In 1954 he was selected to become a member of the staff of the Director of Electronics for the Assistant Secretary of Defense (Research & Development). In this latter position, he was instrumental in establishng the Department of Defense Electronics Test Equipment Coordination Group and served as its first Executive Secretary and later as its Chairman. Since 1957 and until his appointment as Chief, Lt. Colonel Abramovich has been Electronics Staff Officer and Deputy Chief of the ARDC Regional Office, Washington, D. C.

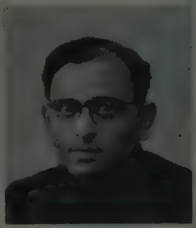
He has been AF member of the Panel on Tubes, Panel on Component Parts, Panel on Test Equipment, and Advisory Group on Reliability of Electronic Equipment of the former Research and Development Board of the Department of Defense. He was also member of Joint Test Equipment Subpanel of the Joint Communication—Electronics Committee, Joint Chiefs of Staff.

Lt. Colonel Abramovich is a member of the American Association for the Advancement of Science, the Institute of Navigation, and was a Charter Member of the Engineers Club of Washington, He is a Registered Professional Engineer of the District of Columbia.

❖

Professor **S. V. C. Aiya** (SM'43) is President of the Institution of Telecommunication Engineers, India, for 1959–60.

The Institution of Telecommunication Engineers, India, was established in November, 1953, on the occasion of the Centenary of the Indian Telegraphs and is the professional institution in India for Telecommunications, Electronics and allied subjects. It has a representative membership drawn from the Government operating telecommunication services, the Armed Forces, research institutions, universities and the telecommunication and electronic industries. Its quarterly journal which publishes research papers, review articles, etc., is abstracted by the leading organizations of the world and has a wide circulation in India and abroad. To enable those without systematic academic training to enter its membership, it conducts examinations which are recognized by the Government of India as equivalent to university degrees in electrical communication engineering.



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(Continued on page 32A)

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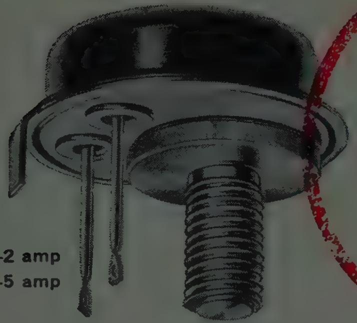
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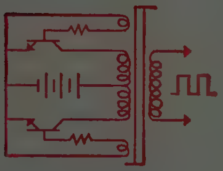

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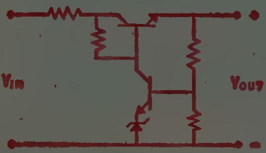

High voltage ratings and high temperature operation, plus internal power dissipation of 150 watts made possible by low thermal resistance of .7°C/watt make the 2N1015 and 2N1016 an ideal choice for constant voltage and constant current regulators.

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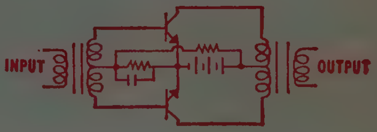
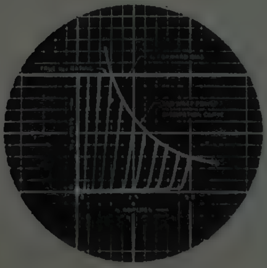


Perfect choice for high power audio and A.C. Amplifier applications, thanks to their high power dissipation capabilities and common emitter frequency response to 20KC.

PLUS TRUE VOLTAGE RATINGS...

guaranteed by 100% power testing. Means you can operate these transistors continuously at the V_{CE} listed for each rating without the risk of transistor failure.

Production quantities of Westinghouse Silicon Power Transistors are available in 2 and 5 ampere collector ratings. Both are available in 30, 60, 100, 150, and 200 volt ratings for immediate applications. Contact your local Westinghouse Apparatus Sales Office, or write directly to Westinghouse Electric Corp., Semiconductor Department, Youngwood, Penna.

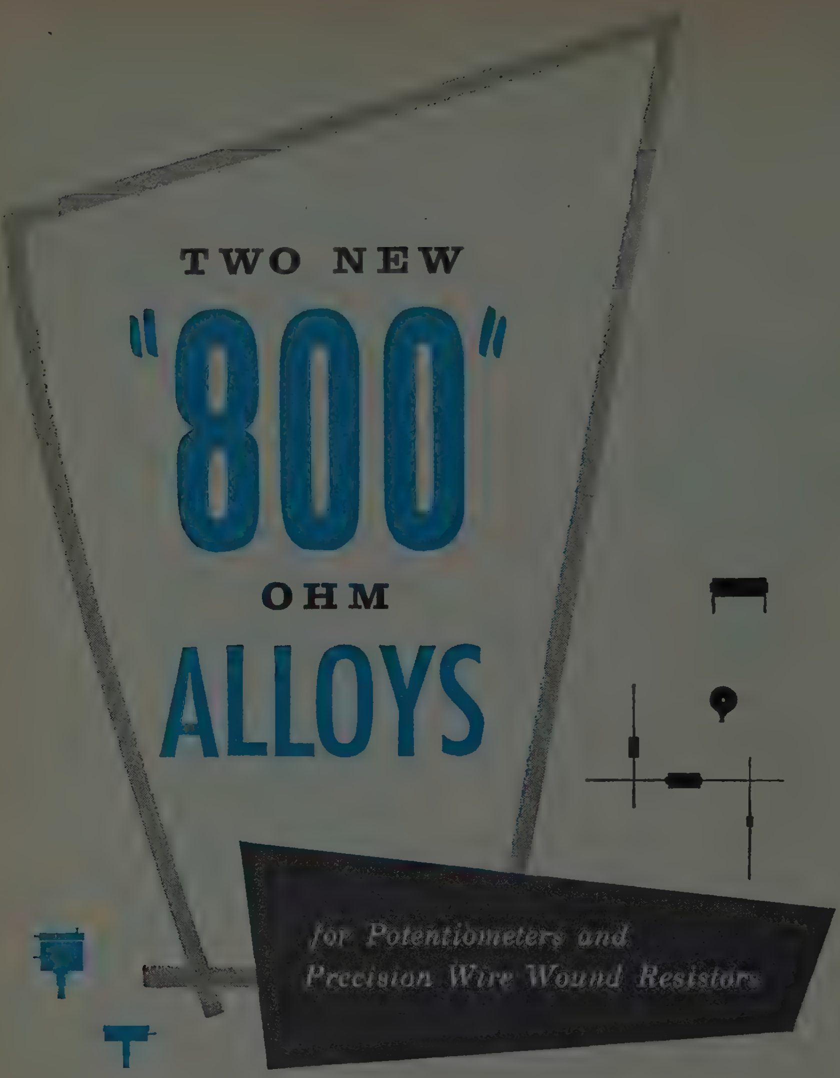


*Designed to meet or exceed military specifications and currently being used in many military, industrial, and commercial applications.

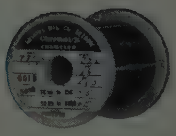
Type	V_{CE}*	β (min)	R_s (max)	I_C A (max)	T_j max. operating	Thermal drop to case (max)
2N1015	30	10 @ I_C=2 amp	.75 ohms @ I_C=2 amp I_B=300 ma	7.5	150°C	.7°C/W
2N1015A	60					
2N1015B	100					
2N1015C	150					
2N1015D	200					
2N1016	30	10 @ I_C=5 amp	.50 ohms @ I_C=5 amp I_B=750 ma	7.5	150°C	.7°C/W
2N1016A	60					
2N1016B	100					
2N1016C	150					
2N1016D	200					

*TRUE voltage rating (The transistors can be operated continuously at the V_{CE} listed for each rating.)

YOU CAN BE SURE...IF IT'S **Westinghouse**

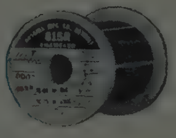


HOSKINS Chromel-R



A modified 80-20 type nickel-chromium alloy possessing optimum uniformity of all physical properties required for close tolerance electronic control applications. Possesses electrical resistivity of 800 ohms/cmf at 20°C. and a low temperature coefficient controlled within 0 ± 10 ppm/°C. Performance characteristics include remarkably low noise level plus exceptional linearity and stability from −65° to +150° C.

HOSKINS Alloy 815-R



A lower density, higher resistivity iron-chromium-aluminum composition that gives you 14% more ohms per pound than nickel-chromium resistor alloys. It possesses high strength, good ductility, excellent resistance to wear and corrosion. Specific resistance is 815 ohms/cmf at 20°C. and temperature coefficient is inherently controlled within 0 ± 10 ppm/°C. over the range from −65° to +150°C.

If you make potentiometers or precision wire wound resistors, these alloys are *right* for you—*right* for your customers, too. Complete technical data—the most comprehensive ever offered—are available upon request, as are sample spools of both alloys taken from current production material. Send for them today!

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4453 Lawton Avenue • Detroit 8, Michigan
Custom-Quality resistance, resistor and thermo-electric alloys since 1908

IRE People

(*Continued from page 30A*)

tion of telecommunication and electronic equipment is arranged. It has several local centers in different parts of India which arrange for periodic paper meetings and discussions.

Professor Aiya, its new President, had a distinguished university career at Bombay and Cambridge (England) and has held positions in academic institutions and universities at Bombay, Poona and Ahmedabad and is now professor and head of the department of Electrical Communication Engineering at the Indian Institute of Science, Bangalore, India's premier research institute. He has from time to time served on several important committees of Government dealing with technical education and research, etc., and assisted the Army authorities in radio work during World War II. He is, at present, a member of the Radio Research Committee of the Indian Council of Scientific Research, the working group on Technical Education of the Indian Planning Commission, the Executive Committee of the Indian Electronics Engineering Research Institute, the Defence Electronics Research Committee, the Expert Committee on Engineering Education of the Institution of Engineers, India, and other committees. He is India's representative on Commission IV of URSI. He is a member of the IEE, London, and the Institution of Engineers, India.

◆

Tore N. Anderson (S'47–A'49–SM'55) has joined FXR, Inc. of Woodside, N. Y. to fill the newly-created position of assistant to Henry Feldmann, the President.

T. N. ANDERSON

Mr. Anderson comes to FXR from Airtron, Inc., a division of Litton Industries. He joined Airtron in 1948, was appointed Chief Engineer in 1951, elected a Director and Vice-President in 1953, and became Director of Engineering in 1956.

He has been Chairman of the Waveguide Connector Standardization Subcommittee of the Electronics Industry Association (EIA) since 1954. He recently participated in meetings held in Ulm, Germany, for the preparation of an international standard of waveguide and wave-

(*Continued on page 34A*)

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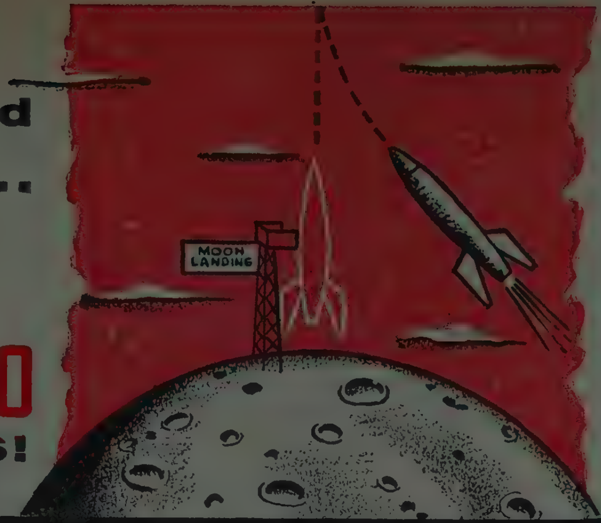

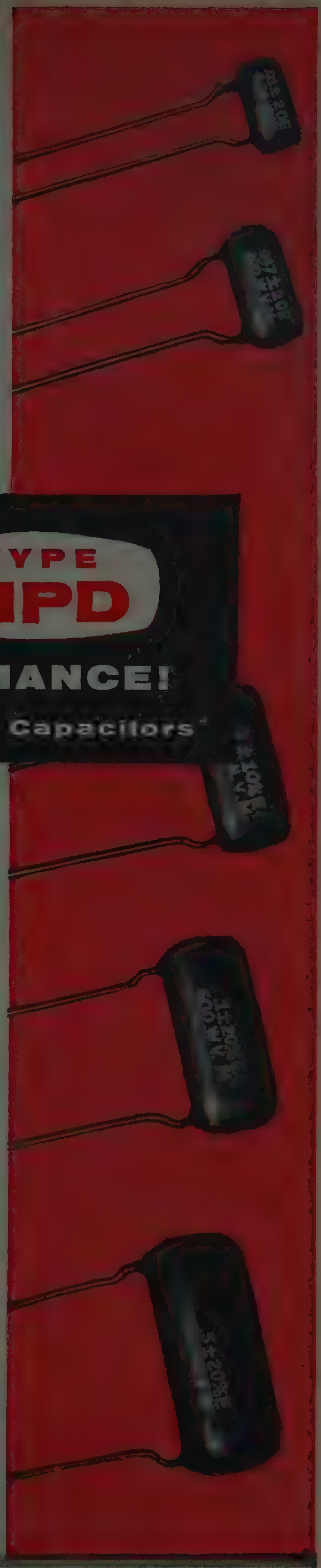

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INSURE FAILURE-PROOF PERFORMANCE!

Only 1 Failure in 7,168,000 Unit-Hours for 0.1 MFD Capacitors

Setting a new standard of reliability!

*Life tests have proved that El-Menco Mylar-Paper Dipped Capacitors — tested at 100°C with rated voltage applied — have yielded a failure rate of only 1 per 716,800 unit-hours for 1 MFD. Since the number of unit-hours of these capacitors is inversely proportional to the capacitance, 0.1 MFD El-Menco Mylar-Paper Dipped Capacitors will yield ONLY 1 FAILURE IN 7,168,000 UNIT-HOURS.

SUPERIOR FEATURES!

- *Five case sizes in working voltages and ranges:*

200 WVDC —	.018 to .5 MFD
400 WVDC —	.0082 to .33 MFD
600 WVDC —	.0018 to .25 MFD
1000 WVDC —	.001 to .1 MMF
1600 WVDC —	.001 to .05 MFD

SPECIFICATIONS

- **TOLERANCES:** ±10% and ±20%. Closer tolerances available on request.
- **INSULATION:** Durez phenolic resin impregnated.
- **LEADS:** No. 20 B & S (.032″) annealed copperweld crimped leads for printed circuit application.
- **DIELECTRIC STRENGTH:** 2 or 2½ times rated voltage, depending upon working voltage.
- **INSULATION RESISTANCE AT 25°C:** For .05MFD or less, 100,000 megohms minimum. Greater than .05 MFD, 5000 megohm-microfarads.
- **INSULATION RESISTANCE AT 100°C:** For .05MFD or less, 1400 megohms minimum. Greater than .05MFD, 70 megohm-microfarads.
- **POWER FACTOR AT 25°C:** 1.0% maximum at 1 KC.

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MPD
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THE ELECTRO MOTIVE MFG. CO., INC.

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Manufacturers of El-Menco Capacitors

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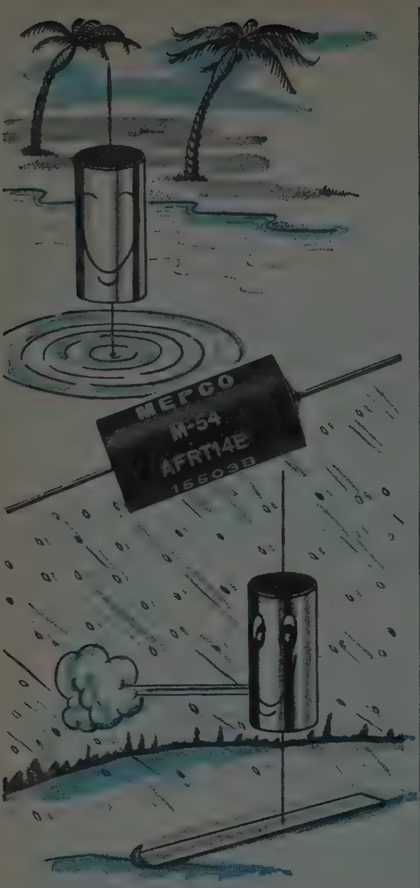

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IRE People

(Continued from page 32A)

guide connectors. In 1959, he was appointed a consultant to the Department of Defense, Advisory Group on Electron Parts, Working Group on Transmission Lines.

Mr. Anderson was Chairman of the Northern New Jersey Section of the IRE and organized the Chapter's Professional Group on Microwave Theory and Techniques. He is now on the Administrative Committee and Editorial Board of the PGMTT of IRE. He is also a member of the American Physical Society and the American Institute of Electrical Engineering. He was elected to Tau Beta Pi and Mu Alpha Omicron. He received the B.S. degree from Cooper Union.

❖

David R. Baldauf (A'52–M'57) has been appointed development engineer in Systems Analysis at the Owego facility of IBM's Federal Systems Division.

He joined IBM in 1952 as a design engineer in Radar Display Development, and was named associate engineer in 1954, project engineer, manager of AN/ASQ-38 Electronic Development in 1955, and advisory engineer, Systems Coordination and Planning in 1958.

Originally from Massillon, Ohio, Mr. Baldauf earned a B.S. degree in Electrical Engineering from Purdue University in 1952. He has taken graduate work through the IBM-Syracuse University program.

He served with the U. S. Navy during World War II as an electronics technician.

❖

The election of **Alfred S. Backus** (A'52–SM'59) as Vice President, Operations, of the Mycalex Corporation of America and its affiliated companies, Mycalex Electronics Corporation, Mycalex Tube Socket Corporation and the Synthetic Mica Company, has been announced by Jerome Taishoff, Mycalex President.

A. S. Backus

Mr. Backus has been serving as Acting General Manager of the Mycalex Corporation of America and its affiliated companies for the past year and has been Works Manager since 1952. He joined the Mycalex Corporation of America in 1944. He served originally as Plant Superintendent, becoming Plant Manager and then Works Manager. Prior to joining Mycalex, he had been employed by the General Electric Company, Chemical Division, in their Pittsfield and Taunton, Mass. plants.

Mr. Backus is a member of the Society of Plastics Engineers and the Society of Metal Production.

❖

(Continued on page 36A)

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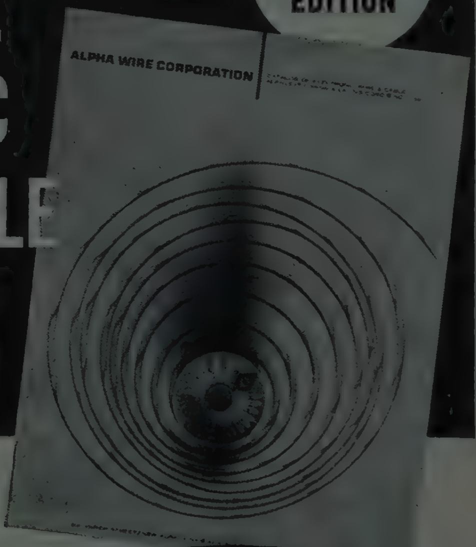

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% GOOD UNITS (RELIABILITY)
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50
25
100
1,000
10,000
100,000
TRANSFORMER A
TRANSFORMER B
ADC

Transformer A and B are identical in appearance. They can both pass electrical inspection tests. The quality of the materials, workmanship, and design are all hidden from view so that no physical inspection can be made. So how do you tell? Which is A, and which is B?

The best way to tell is to know the manufacturer. If you're not already a customer we'd like to number you among those who *know from experience* that they have transformer reliability *inside,* when it says ADC on the *outside.* Over 15,000 custom transformer designs in nearly 25 years have proven beyond a doubt that long life just plain runs in the ADC family.

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IRE People

(Continued from page 34A)

Dr. Peter A Castruccio (SM'57), 34, technical director of the Aerospace Division of Aeronca Manufacturing Corporation in Baltimore, Md., has been named one of the outstanding young men of 1959 by the United States Junior Chamber of Commerce.

Recognition as one of 1959's outstanding young men is based on Dr. Castruccio's pioneering work in astronautics and space technology and his accomplishments in the design and development of a satellite and space ship stabilization system and a space guidance system.

P. A. CASTRUCCIO

Dr. Castruccio's experience covers a broad range of technical activity, including radar systems, navigational systems, circuits, instrumentation, servomechanisms, computers, automation, space technology missile and space system analysis and design, and mechanical engineering.

In 1958, Dr. Castruccio was Director of the Astronautics Institute charged with the technical planning, administration and coordination of space programs for Westinghouse Electric Company. From 1955 to 1957, he was head of the Preliminary Design Section, Air Arm Division of Westinghouse, engaged primarily in systems analysis and preliminary design of the terminal guidance system of the BOMARC long-range interceptor missile.

He previously had been project engineer for four years at Aircraft Armaments, Inc., where he was in charge of systems development and design of equipment associated with the guidance of the TALOS and TERRIER missiles. He began his professional career in 1947 as a member of the research and development department at Bendix Radio, Towson, Maryland, where he was engaged in microwave work and antenna design.

In twelve years with American industry, Dr. Castruccio has to his credit some 200 disclosures and about 20 patents pending or issued.

A member and Vice President of the Maryland Chapter of the American Rocket Society, he received the annual award of the Maryland Chapter of the American Rocket Society in 1958 for his "Outstanding Accomplishments in the Field of Rocketry."

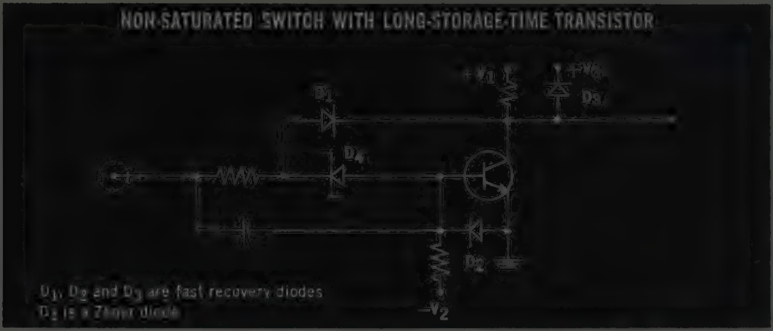
Dr. Castruccio became technical director of Aeronca's Aerospace Division in mid-1959. Creation of the division signaled the formal entry of Aeronca into the space field.

❖

Hazeltine Research Corporation has announced the appointment of **William F. Bailey** (S'33–A'36–VA'39–SM'51–F'54), **Richard J. Farber** (S'45–A'47–SM'54) and **Donald Richman** (S'42–A'45–SM'52) as

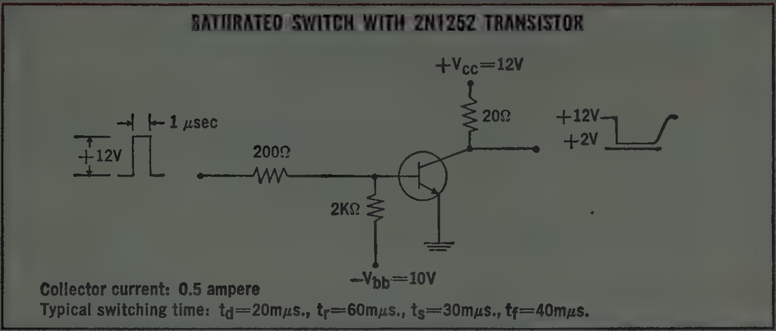
(Continued on page 38A)

RELIABLE SILICON TRANSISTOR SWITCHING


NON-SATURATED SWITCH WITH LONG-STORAGE-TIME TRANSISTOR

D_1, D_2 and D_3 are fast recovery diodes
D_4 is a Zener diode

9 COMPONENTS REPLACED BY 4


SATURATED SWITCH WITH 2N1252 TRANSISTOR

Collector current: 0.5 ampere
Typical switching time: t_d=20mμs., t_r=60mμs., t_s=30mμs., t_f=40mμs.

HOW? — By using Fairchild's 2N1252 or 2N1253 **lowstorage** silicon mesa transistors. The guaranteed low storage characteristic permits a simple saturating circuit to achieve switching speeds that previously required complex non-saturating circuits.

WHY? — Improved reliability and reduced cost — one semiconductor instead of five and fewer soldered connections. Power dissipation is only 1/3rd to 1/5th as great, making possible much higher component densities in packaging. Cost and reliability are improved all the way from development through volume production.

WHERE? — Switching circuits in general. The 2N1252 and 2N1253 are ideally suited to high-speed high-current switching applications such as magnetic-core drivers, drum and tape write drivers, high-current pulse generators and clock amplifiers. In addition, the transistors are applicable to medium-speed saturated logic circuits.

FAIRCHILD 2N1252 and 2N1253

Symbol	Characteristic	Rating	Min	Typ	Max	Test Conditions	
h_{FE}	D.C. pulse current gain 2N1252		15	35	45	I_C=150mA	V_C=10V
	2N1253		30	45	90		
P_C	Total dissipation at 25°C case temperature	2 watts					
$V_{BE\ SAT.}$	Base saturation voltage			0.9V	1.3V	I_C=150mA	I_B=15mA
$V_{CE\ SAT.}$	Collector saturation voltage			0.6V	1.5V	I_C=150mA	I_B=15mA
h_{fe}	Small signal current gain at f=20mc 2N1252		2	4		I_C=50mA	V_C=10V
	2N1253		2.5	5.5			
I_{CBO}	Collector cutoff current			0.1μA	10μA	V_C=20V	T=25°C
				100μA	600μA	V_C=20V	T=150°C
t_s+t_f	Turn off time			75mμs	150mμs	I_C=150mA	I_{B1}=15mA
						I_{B2}=5mA	R_L=40Ω
						Pulse width=10ms	

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Features: M24 measures DC voltage, voltage ratio or resistance in a third of a second, V24 measures DC voltage and voltage ratio at same speed . . . both instruments feature advanced transistoried circuitry and mercury-wetted relays with life in excess of 3 billion readings . . . ±one digit accuracy on DC voltage and voltage ratio . . . completely automatic operation . . . plug-in modular construction . . . AC or low level measurements with plug-in accessories . . . output connectors for continuous data logging. Ranges: DC voltage ±.0001 to ±999.9; DC voltage ratio to ±.9999; resistance .1 ohm to 1 megohm. M24, complete: $5,650.00. V24, complete: $4,950.00. Write today for complete data.

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IRE People

(Continued from page 36A)

associate directors of research.

According to J. B. Dow, president of this subsidiary of Hazeltine Corporation, Mr. Bailey will be responsible for military electronic apparatus research; Mr. Farber will direct the industrial research division and Mr. Richman will head the systems research division. These are new divisions established recently by Hazeltine Research Corporation.

Mr. Bailey holds M.E. and M.S. degrees (1933 and 1941) from Stevens Institute of Technology, where he taught before joining Hazeltine in 1936. Until his appointment, he had been chief engineer of the research division of Hazeltine Research Corporation. In 1954–55, Mr. Bailey was chairman of the Long Island section of the IRE. He is currently chairman of the IRE Committee on Television Systems and a member of the IRE Standards Committee. His articles and papers have appeared in various electronic publications.

W. F. Bailey

An honor graduate of Columbia University in 1944, Mr. Farber received the M.E. degree from New York University in 1951. Prior to joining Hazeltine 13 years ago, he was an instructor in radar techniques at the Massachusetts Institute of Technology. In 1957, he became chief engineer of Hazeltine Research Corporation's development laboratory. He is chairman of the IRE's Radio Interference Committee and secretary of both the Broadcast Television Systems Committee and the National Stereophonic Radio Committee (Panel 1) of the Electronic Industries Association. He has authored many papers and articles in the fields of radio and television.

R. J. Farber

Winner of the IRE 1957 V. K. Zworykin Television Prize, Mr. Richman received the B.E.E. degree from the City College of New York in 1943 and the M.E.E. degree from Brooklyn Polytechnic Institute in 1948. He joined Hazeltine in 1943 and has been chief engineer of the consultig and-special studies division. He has held responsible positions in the company's IFF, FM,

D. Richman

(Continued on page 40A)

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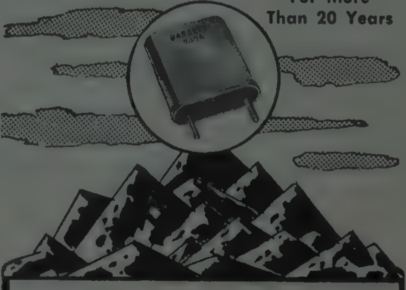

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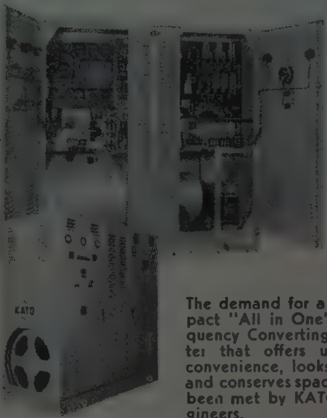

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VA-832
9.79 - 9.81 kMc
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13.3 kMc

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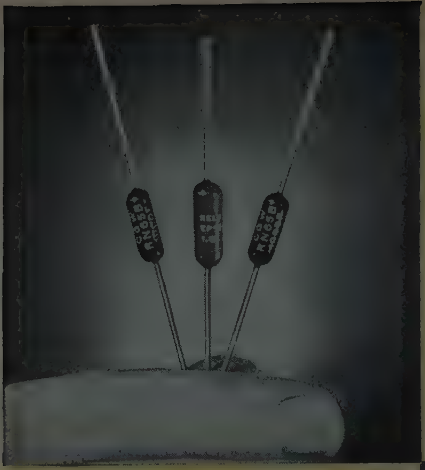

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IRE People

(Continued from page 38A)

super-regeneration, monochrome and color television, direction finding and other programs. He is the author of numerous articles and papers on communications theory, information theory, color systems, super-regeneration, radiation theory and other electronics fields.

All three associate directors of research have been awarded U. S. and foreign patents for their work in electronics.

Hazeltine Research Corporation is planning to expand the staffs of its research divisions, which are now moving into the company's new research and development laboratory in Plainview, Long Island. Mr. Dow said. The establishment of divisions for systems research, military electronic apparatus and circuit research and commercial research are part of a program which will develop creative ideas in the field of communications, navigation, guidance and industrial research demanded by the space age and the expanding electronics needs of industry, Mr. Dow added.

❖

L. S. CHURCHILL, JR.

Lawrence S. Churchill, Jr. (M'57) has joined Stavid Engineering, Inc. as engineering consultant in underwater electromagnetic propagation and ASW projects. He was formerly a member of the technical staff of Bell Telephone Laboratories, Inc., where he was engaged in research and development, and systems engineering in connection with underwater sound and sonar systems. He received the B.S.M.E. degree from the Massachusetts Institute of Technology and the M.S.M.E from the University of Louisville.

He served on the faculty of the University of Louisville as an instructor in mechanics, mechanical design, vibration theory, fluid mechanics, and mechanical laboratory courses. and was Assistant Director of the university's Institute of Industrial Research. Mr Churchill is a member of the American Society of Mechanical Engineers.

❖

I. S. COGGESHALL

Ivan S. Coggeshall (A'26–M'29–F'42) has been appointed to the Headquarters Staff of the American Institute of Electrical Engineers as Manager Of Technical Operations Services. He served as Assistant Vice-President to Western Union Telegraph Company until his retirement on January 1, 1960.

Born September 30, 1896 in Newport, R I., he attended Worcester

(Continued on page 42A)

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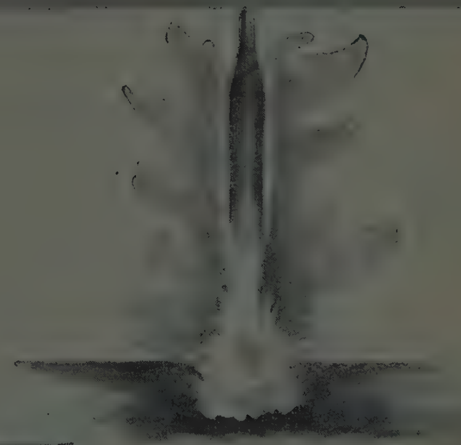

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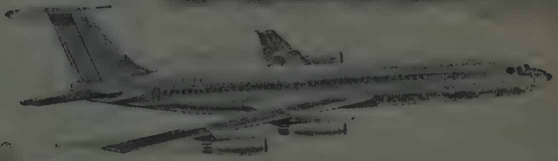

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Today every major commercial and military aircraft including intercontinental and medium range jet bombers, supersonic fighter-bombers and interceptors, trainers, tankers, cargo and reconnaissance planes, are equipped with all-metal mounting systems designed by Robinson to protect many vital components.

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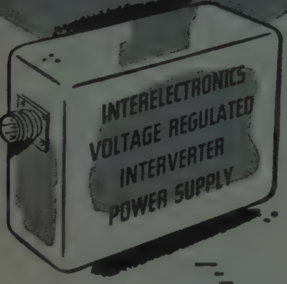

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IRE People

(Continued from page 40A)

Polytechnic Institute, Worcester, Mass. from 1914 to 1917. He received an honorary Doctor of Engineering degree from that institution in 1951. He graduated from the U. S. Navy Steam School, Stevens Institute of Technology, Hoboken, N. J., in 1919. In 1937 he passed the Professional Engineering examination of New York State, and in 1955 he received a Certificate in International Law from the Naval War College in Newport, R. I.

Since 1917, Dr. Coggeshall has worked continuously for Western Union Telegraph Co., except for a year of military service during World War I. He was Director of the Mexican Telegraph Co. from 1939 to 1953, and served as General Traffic Manager, International Communications, from 1946 to 1951. He has served as Ensign, Lieutenant Commander and Commander in the U. S. Naval Reserve Force, and served on the Board of War Communications, Submarine Cables, in World War II.

He has served on several Governmental Boards and Committees; in 1959 he was appointed to the National Industrial Advisory Committee of the Federal Communications Committee. From 1947 to 1959 he was a member of the Western Union interdepartmental Committee on Technical Publication, and associate editor of the "Western Union Technical Review."

(Continued on page 46A)

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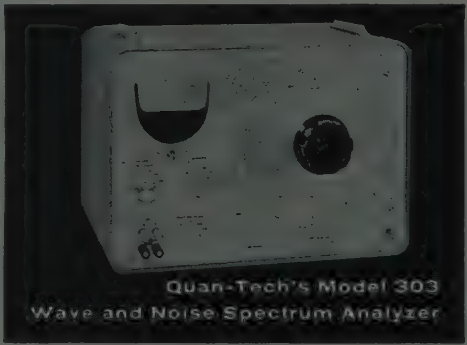

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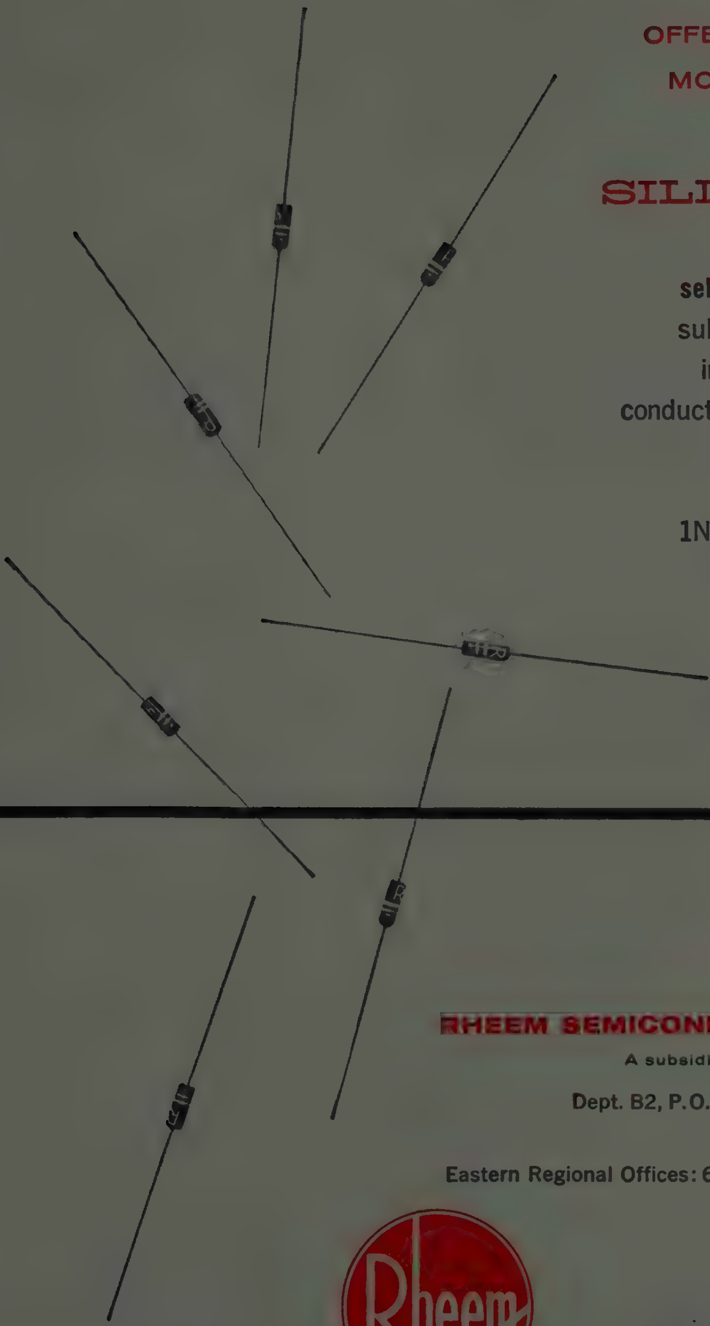

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28 Fields of Special Interest-

The 28 Professional Groups are listed below, together with a brief definition of each, the name of

Aeronautical and Navigational Electronics

Annual fee: $2.

The application of electronics to operation and traffic control of aircraft and to navigation of all craft.

Mr. Lewis M. Sherer, Chairman, RTCA, Washington, D.C.

33 Transactions, *5, *6, & *9, and *Vol. ANE-1, Nos. 2 and 3; Vol. 2, No. 1-3; Vol. 3, No. 2; Vol. 4, No. 1, 2, 3; Vol. 5, No. 2, 3, 4; Vol. 6, No. 1, 3.

Antennas and Propagation

Annual fee: $4.

Technical advances in antennas and wave propagation theory and the utilization of techniques or products of this field.

Mr. Arthur Dorne, Chairman, Dorne & Margolin, Westbury, L.I., N.Y.

27 Transactions, *Vol. AP-2, No. 2; AP-4, No. 4; AP-5, No. 1-4; AP-6, No. 1, 2, 3, 4; AP-7, No. 1, 2, 3, 4.

Audio

Annual fee: $2.

Technology of communication at audio frequencies and of the audio portion of radio frequency systems, including acoustic terminations, recording and reproduction.

Dr. A. B. Bereskin, Chairman, EE Dept., Univ. of Cincinnati, Cincinnati 21, Ohio.

49 Transactions, *Vol. AU-1, No. 6; *Vol. AU-2, No. 1, 4; Vol. AU-3, No. 1, 3, 5; Vol. AU-4, No. 1, 5-6; Vol. AU-5, No. 1, 2, 3, 4, 5, 6; AU-6, No. 1, 2, 3, 4, 5, 6; AU-7, No. 1, 2, 3, 4, 5.

Automatic Control

Annual fee: $2.

The theory and application of automatic control techniques including feedback control systems.

Mr. John E. Ward, Chairman, Servomechanisms Lab., MIT, Cambridge 39, Mass.

7 Transactions, PGAC-3-4-5-6, AC-4, No. 1.

Broadcast & Television Receivers

Annual fee: $2.

The design and manufacture of broadcast and television receivers and components and activities related thereto.

Mr. Robert R. Thalner, Chairman, Sylvania Home Electronics, Batavia, N.Y.

23 Transactions, *7, 8; BTR-1, No. 1-4; BTR-2, No. 1-2-3; BTR-3, No. 1-2; BTR-4, No. 2, 3-4; BTR-5, No. 1, 2.

Broadcasting

Annual fee: $2.

Broadcast transmission systems engineering, including the design and utilization of broadcast equipment.

Mr. George E. Hagerty, chairman, Westinghouse, 122 E. 42nd St., New York 17, N.Y.

14 Transactions, No. 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14.

Circuit Theory

Annual fee: $3.

Design and theory of operation of circuits for use in radio and electronic equipment.

Mr. Sidney Darlington, Chairman, Bell Tel. Labs., Murray Hill, N.J.

25 Transactions, CT-2, No. 4; CT-3, No. 2; CT-4, No. 3-4; CT-5, No. 1, 2, 3, 4, CT-6, No. 1, 2, 3.

Communications Systems

Annual fee: $2.

Radio and wire telephone, telegraph and facsimile in marine, aeronautical, radio-relay, coaxial cable and fixed station services.

Mr. J. E. Schlaijker, Chairman, IT&T, 67 Broad St., New York 4, N.Y.

15 Transactions, CS-2, No. 1; CS-5, No. 2, 3; CS-6, No. 1, 2; CS-7, No. 1, 2, 3.

Component Parts

Annual fee: $3.

The characteristics, limitation, applications, development, performance and reliability of component parts.

Mr. J. J. Drvostep, Chairman, Sperry Gyroscope Co., Great Neck, N.Y.

18 Transactions, Vol. CP-3, No. 2; CP-4, No. 1, 2, 3-4; CP-5, No. 1, 2, 3, 4; CP-6, No. 1, 2, 3, 4.

Education

Annual fee: $3.

To foster improved relations between the electronic and affiliated industries and schools, colleges, and universities.

Dr. John G. Truxal, Chairman, Dept. of EE, PIB, Brooklyn, N.Y.

8 Transactions. Vol. E-1, No. 3, 4; E-2, No. 1, 2, 3, 4.

Electron Devices

Annual fee: $3.

Electron devices, including particularly electron tubes and solid state devices.

Dr. W. M. Webster, Chairman, RCA Labs., Princeton, N.J.

26 Transactions, *Vol. ED-1, No. 3-4; ED-3, No. 2-4; ED-4, No. 2-3, 4; ED-5, No. 2, 3, 4; ED-6, No. 1, 3.

Electronic Computers

Annual fee: $4.

Design and operation of electronic computers.

Mr. Richard O. Endres, Rese Engineering Co., 731 Arch St., Philadelphia, Pa.

31 Transactions, EC-6, No. 2, 3; EC-7, No. 1, 2, 3, 4; EC-8, No. 1, 2, 3.

Engineering Management

Annual fee: $3.

Engineering management and administration as applied to technical, industrial and educational activities in the field of electronics.

Dr. Henry M. O'Bryan, Sylvania Elec. Products, 730 3rd Ave., New York 17, N.Y.

16 Transactions, EM-3, No. 2, 3; EM-4, No. 1, 3, 4; EM-5, No. 1-4; EM-6, No. 1, 2, 3.

Engineering Writing and Speech

Annual fee: $2.

The promotion, study, development, and improvement of the techniques of preparation, organization, processing, editing, and delivery of any form of information in the electronic-engineering and related fields by and to individuals and groups by means of direct or derived methods of communication.

Mr. T. T. Patterson, Jr., Chairman, RCA Bldg. 13-2, Camden, N.J.

4 Transactions, Vol. EWS-1, No. 2; EWS-2, No. 1, 2.

Human Factors in Electronics

Annual fee: $2.

Development and application of human factors and knowledge germane to the design of electronic equipment.

Mr. Curtis M. Jansky, Chairman, Royal McBee Corp., Port Chester, N.Y.

THE INSTITUTE OF RADIO

-IRE's 28 Professional Groups

the group chairman, and publications to date.

*** Indicates publications still available**

Industrial Electronics

Annual fee: $3.

Electronics pertaining to control, treatment and measurement, specifically, in industrial processes.

Mr. J. E. Eiselein, Chairman, RCA Victor Dev., Camden, N.J.

10 Transactions, *PGIE-1-3-5-6-7-8, 9, 10.

Information Theory

Annual fee: $3.

Information theory and its application in radio circuitry and systems.

Dr. Peter Elias, Chairman, MIT, Cambridge 39, Mass.

18 Transactions, PGIT-4. IT-1, No. 2-3; IT-2, No. 3; IT-3, No. 1, 2, 3, 4; IT-4, No. 1, 2, 3, 4; IT-5, No 1 2, 3

Instrumentation

Annual fee: $2.

Measurements and instrumentation utilizing electronic techniques.

Mr. C. W. Little, Jr., Chairman, C-Stellerator Assoc., Princeton, N.J.

16 Transactions, 4; Vol. 1-6, No. 2, 3, 4; Vol. 1-7, No. 1, 2; Vol. 1-8, No. 1, 2, 3.

Medical Electronics

Annual fee: $3.

The use of electronic theory and techniques in problems of medicine and biology.

Mr. W. E. Tolles, Chairman, Airborne Instruments Lab., Mineola, N.Y.

15 Transactions, 8, 9, 11, 12, ME-6, No. 1, 2, 3.

Microwave Theory and Techniques

Annual fee: $3.

Microwave theory, microwave circuitry and techniques, microwave measurements and the generation and amplification of microwaves.

Dr. A. A. Oliner, Microwave Research Institute, 55 Johnson St., Brooklyn 1, N.Y.

27 Transactions, MTT-4, No. 3-4; MTT-5, No. 3, 4; MTT-6, No. 1, 2, 3, 4; MTT-7, No. 2, 3, 4.

Military Electronics

Annual fee: $2.

The electronics sciences, systems, activities and services germane to the requirements of the military. Aids other Professional Groups in liaison with the military.

Mr. Henry Randall, Chairman, Office of Asst. Secy. Defense, Pentagon, Washington, D.C.

7 Transactions, MIL-1, No. 1; MIL-2, No. 1; MIL-3, No. 2, 3, 4

Nuclear Science

Annual fee: $3.

Application of electronic techniques and devices to the nuclear field.

Dr. A. B. Van Rennes, Chairman, United Research, Inc., Cambridge, Mass.

14 Transactions, NS-1, No. 1; NS-3, No. 2, 3; NS-4, No. 2; NS-5, No. 1, 2, 3, NS-6, No. 1, 2, 3.

Production Techniques

Annual fee: $2.

New advances and materials applications for the improvement of production techniques, including automation techniques.

Mr. L. M. Ewing, Chairman, General Electric Co., Syracuse, N.Y.

6 Transactions, No. 2-3, 4, 5, 6.

Radio Frequency Techniques

Annual fee: $2.

Origin, effect, control and measurement of radio frequency interference.

Mr. J. P. McNaul, Chairman, Signal Corps, USA's RDL, Ft. Monmouth, N.J.

1 Transaction, RF-1, No. 1.

Reliability and Quality Control

Annual fee: $3.

Techniques of determining and controlling the quality of electronic parts and equipment during their manufacture.

Mr. P. K. McElroy, Chairman General Radio Co., West Concord, Mass.

16 Transactions, *3, 5-6, 10, 11, 12, 13, 14, 15, 16.

Space Electronics and Telemetry

Annual fee: $2.

The control of devices and the measurement and recording of data from a remote point by radio.

Mr. C. H. Hoeppner, Chairman, Radiation, Inc., Melbourne, Fla.

14 Transactions, TRC-1, No. 2-3; TRC-2, No. 1; TRC-3, No. 2, 3; TRC-4, No. 1; SET-5, No. 1, 2, 3, 4.

Ultrasonics Engineering

Annual fee: $2.

Ultrasonic measurements and communications, including underwater sound, ultrasonic delay lines, and various chemical and industrial ultrasonic devices.

Dr. Wilfred Roth, Chairman, Roth Lab., Hartford, Conn.

7 Transactions, PGUE, 5, 6, 7.

Vehicular Communications

Annual fee: $2.

Communications problems in the field of land and mobile radio services, such as public safety, public utilities, railroads, commercial and transportation, etc.

Mr. A. A. MacDonald, Chairman, Motorola, Inc., 4545 W. Augusta Blvd., Chicago 51, Ill.

13 Transactions, 5, 8, 9, 10, 11, 12, 13.

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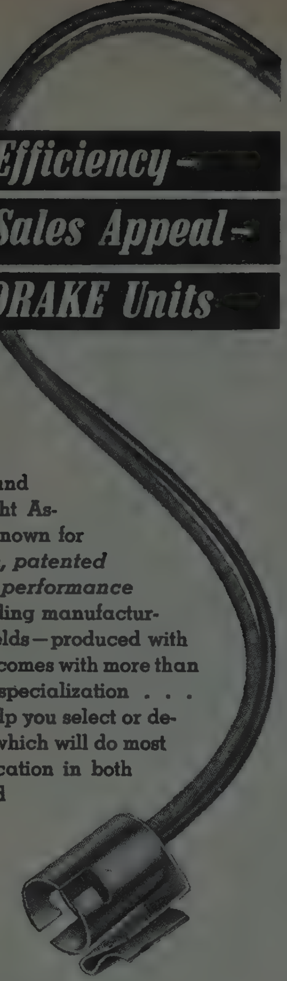

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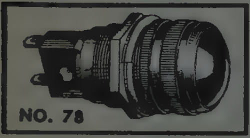
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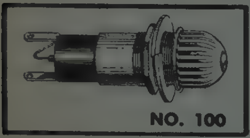
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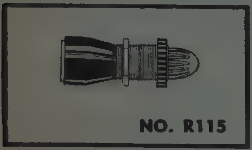
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IRE People

(Continued from page 42A)

He has also authored several engineering papers and articles, and written many book reviews.

Dr. Coggeshall is a Fellow of the AIEE and a member of Tau Beta Pi. He is a Past President and Director of the IRE.

❖

Robert B. Corby (M'56) has been appointed to the position of Staff Engineer in the Program Planning Department of Motorola's Western Military Electronics Center, it was announced by Harvey M. Ross, Program Planning Manager.

R. B. Corby

In his new position he will be responsible for the development of new areas of product and program activities. This will include the analysis, organization and coordination of technical and promotional effort required to match Motorola's skills most appropriately to the military's needs.

He joined Motorola in 1953 as Assistant Manager in Microwave Products in Chicago, Ill. In 1955 he became Manager of Military Microwave Sales and in 1958 was transferred to the Military Electronics Division in Phoenix, Ariz. as marketing coordinator for the company's six military plants. Prior to joining Motorola, Mr. Corby had extensive electronics engineering and administrative experience and during World War II was Navy liaison representative to the M.I.T. Radiation Laboratory. A graduate of Union College with the B.S.E.E. degree in 1941, he holds the M.S. degree in marketing from the University of Chicago.

❖

Dr. Lloyd T. DeVore (A'42–SM'44–F'52) has been appointed director of engineering of the Laboratories Division, Hoffman Electronics Corp., President H. Leslie Hoffman announced.

The appointment was made to coordinate more effectively the division's research and engineering activity with advanced research at the Hoffman Science Center in Santa Barbara, Calif., which Dr. DeVore also heads.

The new engineering director joined Hoffman a year ago, as a corporate vice president and director of the Science Center, which engages in advanced, product oriented research in some of the promising new fields in electronics.

He began his career as a physics instructor at Pennsylvania State College after receiving the B.S. degree in 1930, the M.S. degree in 1931 and the Ph.D. degree in 1933. In 1942 he became chief engineer

(Continued on page 48A)

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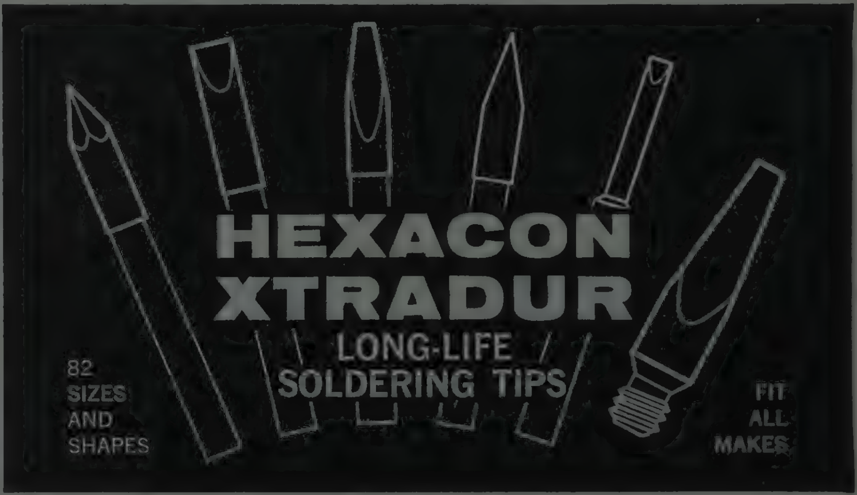

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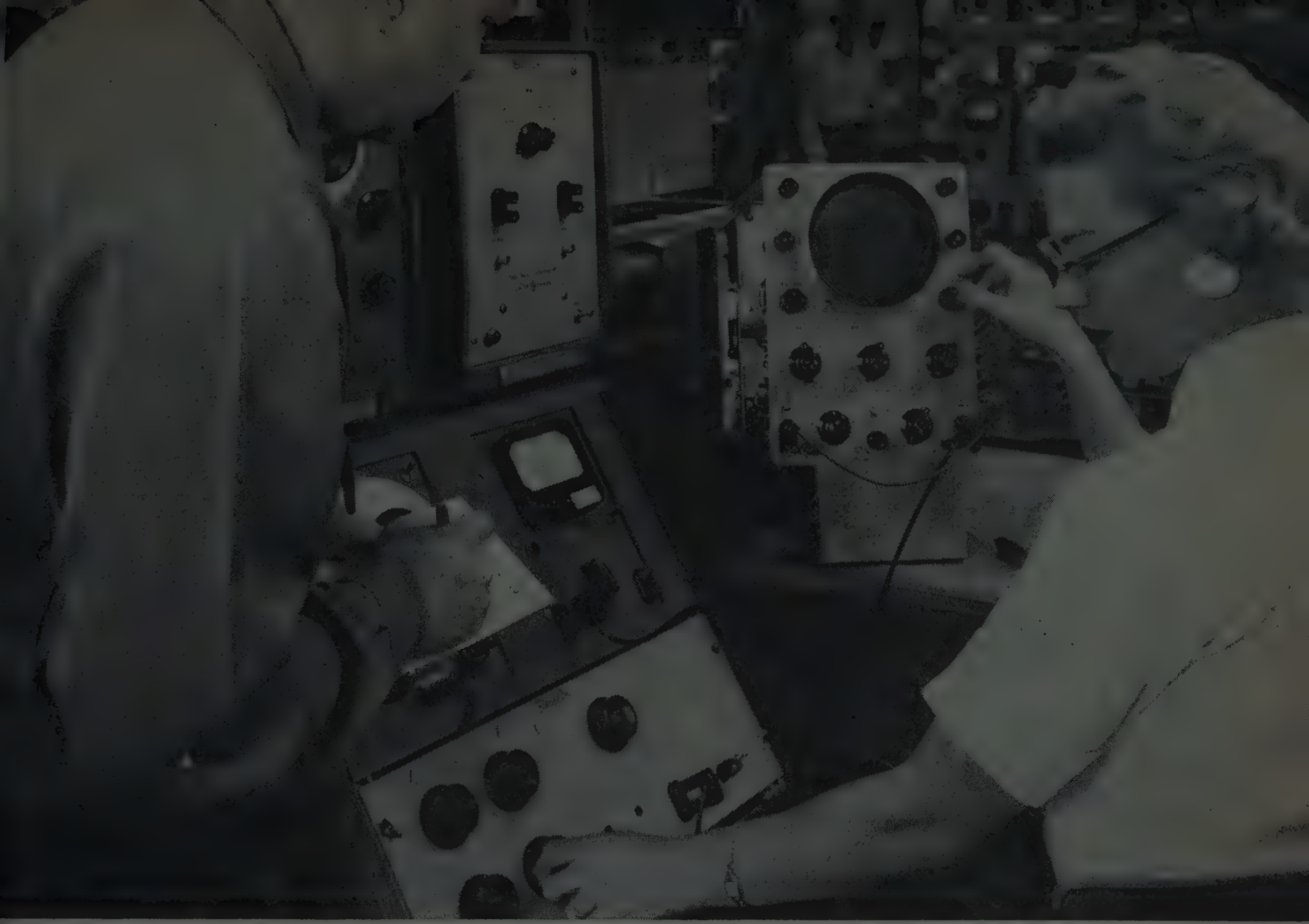

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What this means, of course, is that under varying loads the 6550 drive, with its tight characteristics, holds to a minimum any change in the unit's already minimal distortion (less than 0.2%). In addition the 6550 helps to provide long-term stability.

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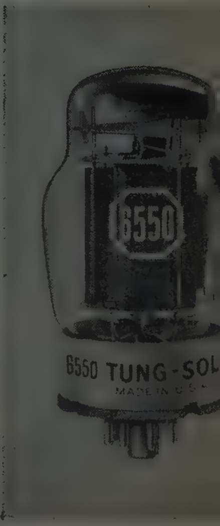

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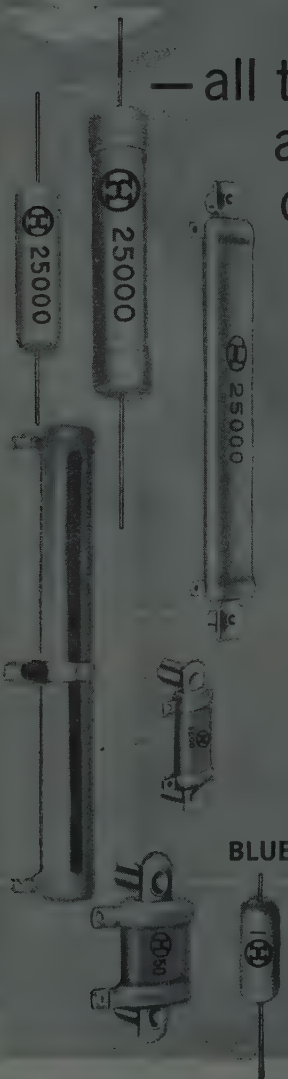

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Design for Reliability with the Hardwick, Hindle "Gray Line"*

These high reliability components incorporate special design and construction features that assure the highest degree of dependability under the most adverse operating conditions. Non-crazing high temperature gray enamel, stronger core, welded wire connections, higher shock resistance, immunity to salt spray and humidity are advantages inherent in all H-H resistors. Fixed, ferrule and adjustable types comply with MIL-R-26 specifications and meet EIA standards.

***Where Space is a Factor —** specify H-H Blue Ribbon Space Saver Resistors. Sold through authorized H-H distributors nationwide. Call or write for catalog including both Gray Line and Blue Ribbon Resistors, MIL Types, mounting brackets and accessories. Ask for your copy, now!

The Mark of Quality since 1924

HARDWICK, HINDLE · INC
40 HERMON ST., NEWARK 5, NEW JERSEY

IRE People

(Continued from page 46A)

of the Special Projects Laboratory, Wright Field, specializing in radio and radar communications and in guided missiles. After World War II he joined the University of Illinois, where he became chairman of the Research Committee and coordinator of research for the Department of Electrical Engineering.

Dr. DeVore left the university in 1950 to become manager of General Electric Company's Electronics Laboratory in Syracuse, N. Y., serving five years before accepting an assignment as general manager of the Electronics Division, Stewart-Warner Corporation.

He is a fellow of the American Association for the Advancement of Science, and a member of the American Physical Society, American Management Association and of the Armed Forces Communications and Electronics Association.

❖

Airborne Instruments Laboratory (AIL), Deer Park, N. Y., yesterday announced the appointments of **Dr. E. G. Fubini** (A'36–SM'46–F'54) and **Dr. G. C. Comstock** (A'47–M'47–SM'51–F'57) as vice presidents. Dr. Fubini and Dr. Comstock formerly were co-directors of AIL's Research and Engineering Division. AIL is a division of Cutler-Hammer, Inc.

Dr. Comstock was appointed vice president of the Electronic Systems and Techniques Division of Airborne Instruments Lab.

G. C. Comstock

He has been concerned with the system development of radars and radar data utilization since early 1942, when he joined the staff of the Radiation Laboratory, Massachusetts Institute of Technology. At that time, his effort was devoted to the early development of instrument landing radar systems.

He received the B.S. degree at Bradley University in 1932 and the Ph.D. degree in Physics from the University of Chicago in 1938, and served as Assistant Professor of Physics at the Citadel until 1942, when he went to M.I.T.

At M.I.T. in 1943, he was in charge of the electronics engineering for the original GCA (Ground Controlled Approach) radar. Subsequently, he served as GCA Project Leader and an Associate Chairman of the Ground Radar Division during the initial development of airport traffic control radar.

In 1946, shortly after joining AIL, he became Assistant Supervising Engineer of the Air Navigation and Traffic Control Section, and in 1950 Supervising Engineer of the Operational Development Section and later of the Radar and Navigation Section. From 1955 through 1959, he was

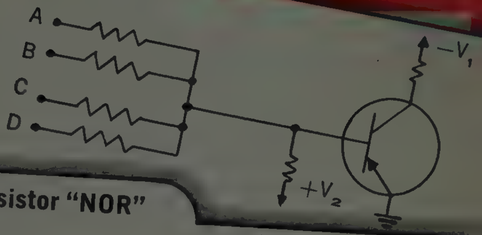
(Continued on page 54A)

Semiconductor News from SYLVANIA Quality-by intention!

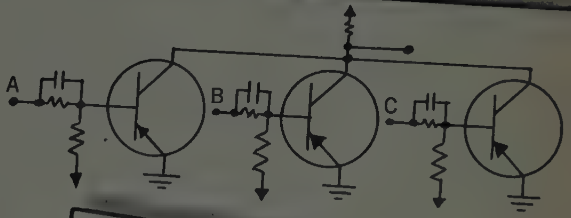
Sylvania NPN and PNP Transistors controlled specifically for switching service

Rigid adherence to high standards of performance and electrical uniformity is assured through the exercise of stringent quality controls. High reliability under severe environmental conditions is assured by thorough final-test procedures. Sylvania switching transistors are in TO-5 cases with welded hermetic seal. Shown here are a number of switching circuits designed around Sylvania transistors and diodes.

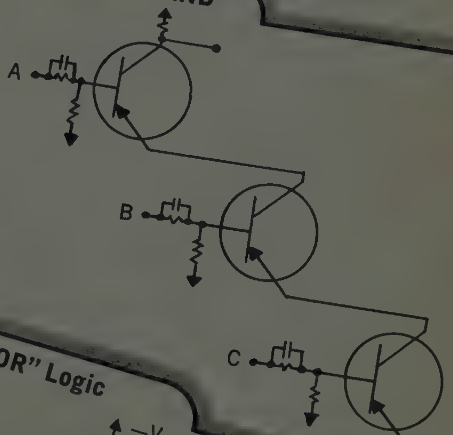
"NOR" Logic



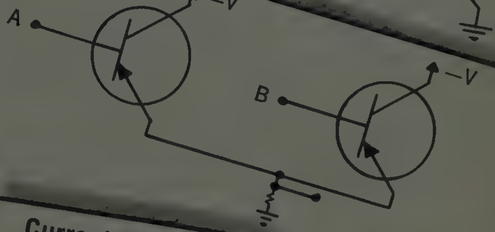
Transistor "NOR"



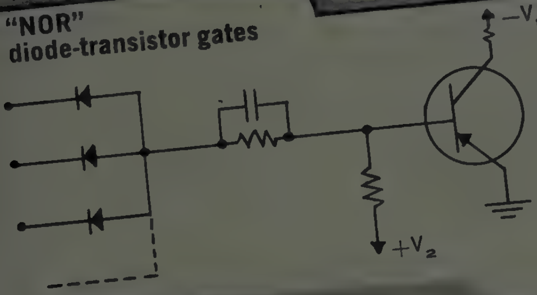
Transistor "AND"



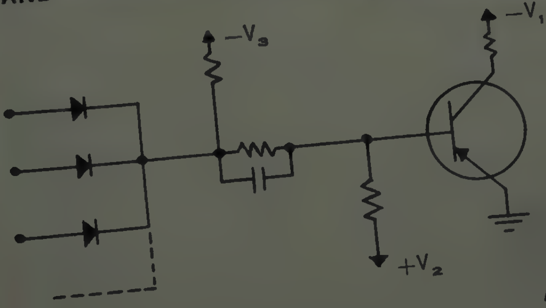
"OR" Logic



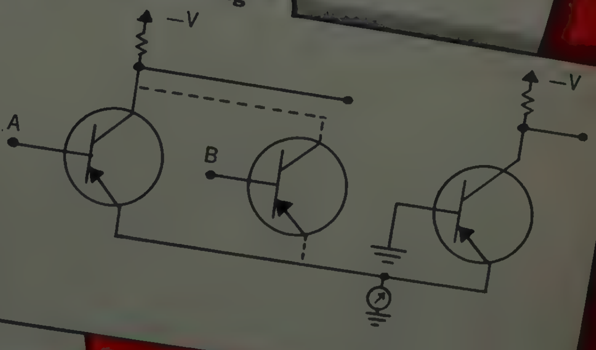
"NOR" diode-transistor gates



"NAND" diode-transistor gates



Current Switching



SYLVANIA NPN AND PNP SWITCHING TRANSISTORS

Reliable performers in military and computer applications

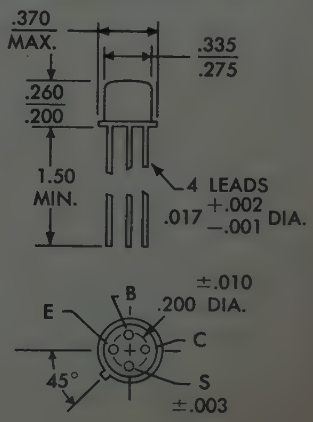
ELECTRICAL CHARACTERISTICS

NPN Type	COLLECTOR TO BASE VOLTS (Min.)	EMITTER TO BASE VOLTS (Min.)	POWER DISS. AT 25°C (Max.)	FREQ. CUTOFF, FAB V_{CB}=6v. 1c=1ma (Min.)
2N312	15V	15V	100mW	3.0Mc
2N356	20V	20V	100mW	3.0Mc
2N357	20V	20V	100mW	6.0Mc
2N358	20V	20V	100mW	—
2N377	25V	15V	150mW	2.5Mc
2N377A	40V	15V	200mW	2.5Mc
2N385	25V	15V	150mW	4.0Mc
2N385A	40V	15V	200mW	4.0Mc
2N388	25V	15V	150mW	5.0Mc
2N388A	40V	15V	200mW	5.0Mc
2N438	30V	25V	100mW	2.5Mc
2N438A	30V	25V	150mW	2.5Mc
2N439	30V	25V	100mW	5.0Mc
2N439A	30V	25V	150mW	5.0Mc
2N440	30V	25V	100mW	10.0Mc
2N440A	30V	25V	150mW	10.0Mc
2N556	25V	10V	100mW	—
2N557	20V	10V	100mW	—
2N558	15V	5V	100mW	—
2N576	20V	15V	200mW	5.0Mc
2N576A	40V	15V	200mW	5.0Mc
2N585	25V	20V	120mW	3.0Mc
2N587	40V	40V	150mW	—
2N679	25V	15V	150mW	2.0Mc
2N1302	25V	25V	150mW	3.0Mc
2N1304	25V	25V	150mW	5.0Mc
2N1306	25V	25V	150mW	10.0Mc
2N1308	25V	25V	150mW	15.0Mc
2N1114	25V	15V	150mW	7.0Mc
2N1299	40V	15V	150mW	4.0Mc

PNP Type	COLLECTOR TO BASE VOLTS (Min.)	EMITTER TO BASE VOLTS (Max.)	POWER DISS. AT 25°C (Max.)	FREQ. CUTOFF, FAB V_{CB}=5 1e=1mA (Min.)
2N123	−20V	−10V	150mW	5.0Mc
2N404	−25V	−12V	150mW	4.0Mc
2N414	−30V	−12V	150mW	5.0Mc
2N425	−30V	−20V	150mW	2.5Mc
2N426	−30V	−20V	150mW	3.0Mc
2N427	−30V	−20V	150mW	5.0Mc
2N428	−30V	−20V	150mW	10.0Mc
2N519	−25V	−15V	150mW	0.5Mc
2N582	−25V	−12V	150mW	14.0Mc
2N1009	−10V	—	120mW	0.5Mc
2N1381	−25V	−15V	150mW	0.5Mc

SYLVANIA 2N624 "DRIFT" TRANSISTOR FOR TUNED-AMPLIFIER SERVICE TO 12.5 MC

Sylvania 2N624 is a hermetically sealed PNP diffused-base transistor. The package has JEDEC TO-12 dimensions and lead spacings. A fourth lead provides a connection to the metal case for improved shielding. Characteristic testing includes many environmental parameters to assure reliable operation under conditions which may be expected in military applications. Sylvania 2N624 conforms to the requirements for military electronics equipment.



SYLVANIA DIODES—Sylvania manufactures all types of diodes for service as gates, clippers, clampers, detectors; diodes for applications in communications equipment, switching circuits in electronic computers operating at high speeds in the order of millimicroseconds, and special-purpose electronic devices.

SYLVANIA facilities for life and environmental testing include salt spray, moisture, high altitude, vibration, shock, high and low temperatures. SYLVANIA manufacturing and testing facilities are highly automated and mechanized to assure extraordinary electrical uniformity. Many SYLVANIA diodes are available with specifications conforming to military requirements.

POINT-CONTACT DIODES

feature low cost, low capacitance, and exceptionally fast recovery time. Available in all-glass "min" package with power dissipation capabilities to 80mW. Available in solder-seal package for wire-in or clip-in use with power dissipation capabilities to 225mW.

GOLD BOND DIODES

feature high forward-conduction and good recovery-time in units that are relatively low in cost. Available in all-glass "min" package with power dissipation capabilities averaging 80mW.

VLI (very low impedance) DIODES

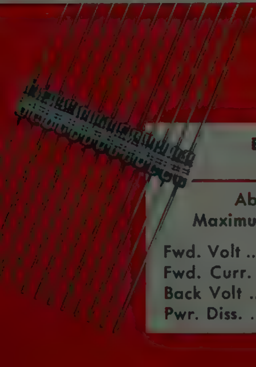
feature very high conduction and relatively high voltage-breakdown. Available in all-glass "min" package with power dissipation capabilities averaging 80mW. Available in solder-seal package for wire-in or clip-in use with increased power dissipation capabilities to 225mW.

SILICON-JUNCTION DIODES

feature high conduction, good recovery time plus the environmental capabilities of silicon—the ability to withstand wide variations in ambient temperature. Available in all-glass "min" package with power dissipation capabilities to 200mW.

SYLVANIA D-1820 HIGH-SPEED SWITCHING DIODE

4 millimicroseconds guaranteed maximum recovery time!



ELECTRICAL CHARACTERISTICS—SYLVANIA D-1820

Absolute Maximum Ratings*	Typical Operating Conditions*
Fwd. Volt ....1.3 V †	Fwd. Volt..............0.9 V
Fwd. Curr. ....50 mA	Fwd. Curr. ....2.0 µA
Back Volt ....20 V	Rev. Recovery........2.5 mµs
Pwr. Diss. ....80 mW	

†at 10 mA *at 20° C.

SYLVANIA D-1820—now available in commercial quantities—is designed, produced and controlled specifically for logic circuitry. The cost of this SYLVANIA diode is low enough to make it especially attractive for use in quantity-produced electronic computers. SYLVANIA D-1820 and circuits designed around it feature: high-speed operation • long-life performance • high reliability • exceptional uniformity • economy • simplicity • compactness.

ACTUAL SIZE

SYLVANIA 2N705 and 2N710 GERMANIUM-MESA COMPUTER TRANSISTORS

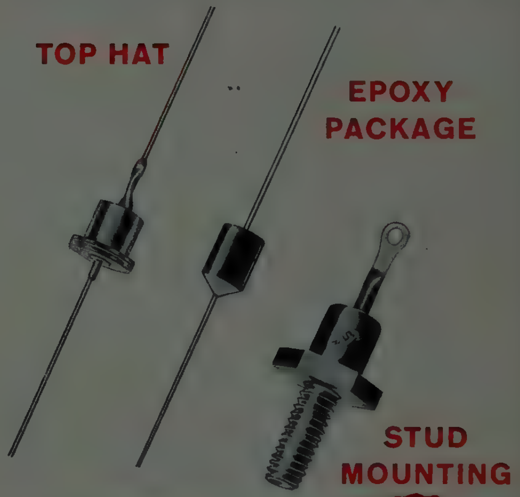
DEPENDABLE! AVAILABLE!

Experienced designers of electronic computers have learned they can depend on the performance of high-speed switching circuits designed around Sylvania transistors. An exceptionally high degree of dependability is built into SYLVANIA Mesa transistors. There are 31 in-line quality control check-points for SYLVANIA 2N705 and 2N710 Mesa transistors. Another important reason for designing around SYLVANIA 2N705 and 2N710: they are available now.

A COMPREHENSIVE LINE OF SILICON RECTIFIERS

The latest in production equipment plus the most modern test procedures are devoted to the manufacture of SYLVANIA silicon rectifiers. Clinically controlled atmospheres on the production line minimize contaminants, result in units that feature low leakage and promise long-life operation.

SYLVANIA silicon rectifiers are quality-controlled for applications in *industrial power supplies* and *magnetic amplifiers*. SYLVANIA silicon rectifiers are available with peak-inverse-voltage ratings to 1000-Volts, and forward-current ratings to 750-mA.



SYLVANIA—RELIABLE SEMICONDUCTORS TO THE TELEPHONE INDUSTRY!

SYLVANIA semiconductor devices are available from your local franchised SYLVANIA SEMICONDUCTOR DISTRIBUTOR or through the FIELD OFFICE nearest you. For technical data, write: SYLVANIA SEMICONDUCTOR DIVISION, WOBURN, MASSACHUSETTS.

SYLVANIA

Subsidiary of ***GENERAL TELEPHONE & ELECTRONICS***

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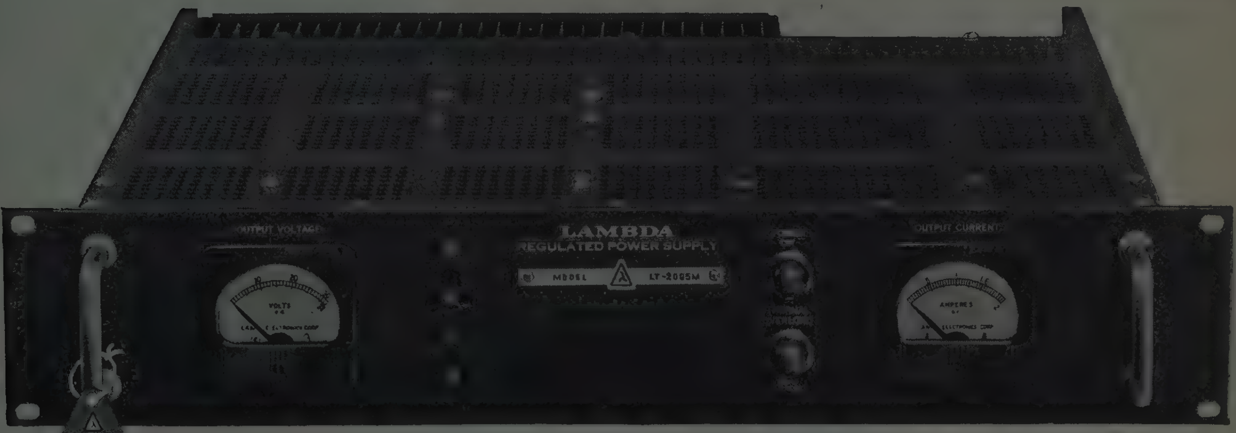
1964

IF YOU INSTALL LAMBDA POWER SUPPLIES NOW, YOU KNOW THEY'LL STILL PERFORM TO GUARANTEE IN 1965



5-Year Guarantee

BECAUSE ONLY LAMBDA GIVES YOU A 5-YEAR GUARANTEE!

Each Lambda Power Supply carries a written guarantee that warrants full performance to specified ratings for five full years.

Lambda, alone, offers this unprecedented guarantee because Lambda specializes in the design and manufacture of just one product — power supplies.

Each unit is built from the ground up to rigid quality standards in a modern, completely integrated plant. Nothing is overlooked to provide you with the finest performance. When you buy a Lambda Power Supply, you are assured of a unit that is conservatively rated — a unit designed to provide continuous-duty service at all specified loads and ratings.

Lambda power supplies are available in a wide range of rack, portable and bench models for laboratory and production service. Of particular interest to electronic designers are:

L-T Transistor-Regulated Series	**0-1 and 0-2 AMP, 0-32 VDC**
Com-Pak Tube Regulated Series	**200-400-800-1500 MA 0-200, 125-325, 325-525 VDC**

Write for free 32-page catalog for complete specifications, dimensions, performance ratings and prices on Lambda's full line of tube-regulated and transistorized power supplies.

Lambda Power Supplies

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SEALED
ELAPSED TIME
INDICATORS

SCHEDULE MAINTENANCE — STUDY PRODUCTIVITY

Glass-to-metal sealed ELAPSED TIME indicators. Compact, low cost, tamper-proof. Standard ASA/MIL dimensions, 2½" and 3½" sizes. Easy to read standard size counter registers 1/10 hour steps to 9999.9 or hour steps to 99999. Hermetically sealed. Shielded. Starts, operates continuously from — 55°C to +85°C. For 110-125 or 220-250 volts 60 cycle AC. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N. H., U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

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quick-disconnect
or permanently connected

MODULOK*
terminal block
with snap-in, spring-loaded contacts

True versatility in a terminal block. 30 modules (2 or 4 tier) per foot. Twist of a screwdriver transforms quick-disconnect contacts to permanent connections.

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SEAL PROBLEMS? A CASE IN POINT

PROBLEM:
GENERAL ELECTRIC required development of a rugged, compact high current hermetic seal CONTROLLED RECTIFIER housing constructed of materials and processes to withstand temperatures above soft solder range—design involves 5 seals to dissimilar materials.

SOLUTION:
Mechanical requirement dictated use of 3 metals: alloy #52, OFHC and Gr "A" Ni. Braze material selected is above 1435°F. so that subsequent welding or brazing can be done without detrimental effect. Tapered seals eliminate costly ground ceramics.

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IRE People

(Continued from page 48A)

co-director of the Research and Engineering Division of AIL

Since 1949, he has also served on many Department of Defense research and development committees and working groups. He has been a member of the Research and Development Board's Panel on Air Navigation and chairman of the subpanel on Short-Distance Navigation Aids, chairman of an RDB Working Group on Counter-Countermeasures for the Guidance and Control of Guided Missiles, a member of the Air Defense System Engineering Committee of the Air Force Scientific Advisory Board, participant in the Project Charles Air Defense Study, consultant for the Technical Advisory Panel on Electronics to the Department of Defense, served with the Weapons Systems Evaluation Group, Office of the Secretary of Defense on special defense studies, and most recently on the Air Defense Panel of Presidential Scientific Advisory Committee.

Dr. Comstock has been active with the Navigation Aids Committee of IRE and is presently serving as secretary-treasurer of the Professional Group on Engineering Management.

Dr. Fubini was appointed vice president of the Research and Systems Engineering Division of Airborne Instruments Lab. During the period 1942 to 1945, as a Research Associate of the Harvard University Radio Research Lab., he was concerned with the design, development, operation, and planning of countermeasure and ferret reconnaissance equipment. During 1943 and 1944 he was a Scientific Consultant and Technical Observer to the U. S. Army and U. S. Navy in the European Theatre of Operations, where he participated in the establishment of electronic reconnaissance and jamming capabilities for the invasion of Italy and of Southern France.

E. G. FUBINI

During 1944 and 1945 he was in England with the U. S. Eighth Air Force in charge of electronic reconnaissance and countermeasures. During 1945 he was a special consultant for ECM to the Office of the Air Communication Officer of the War Department.

He joined AIL as an engineer in 1945, where he was concerned with the development of microwave components, magnetic detectors, electronic test equipment, boundary value problems, AJ devices, antennas, direction finders, and reconnaissance systems.

Under his supervision, AIL became involved in such developments as APR-9 Receivers, ARA-25 Direction Finders, ASQ-8 Magnetic Airborne Detectors, Around-the-Mast Rotary Joints, AN

(Continued on page 56A)

Stabilized two-stage flame, no additives

One of a series

The burning question of cool flames

Between the brief stage of not burning and burning, many hydrocarbons react with oxygen at temperatures well below that of normal flame combustion. But the reactions are usually transient and hard to analyze. At the General Motors Research Laboratories, we have been able to investigate the *effect of chemical additives on cool preflames.*

To do this, the almost invisible cool flames are stabilized for hours in a flat-flame burner, permitting careful examination of the retardation or acceleration effects of the additives. From more than twenty additives studied, experimental results indicate that some chemicals affect combustion through the mechanism of preflame reactions. We are now accumulating new information on these additives' mode of operation. For instance: emission spectra support the conclusion that tetraethyl lead reacts with the oxygenated compounds formed in cool flames to yield lead oxide vapor. These findings of when and how lead oxide is formed are important in resolving a current controversy of science — the combustion behavior of tetraethyl lead.

Studies such as this may lead to more economical and effective means of controlling unrestrained combustion — such as "knock" in reciprocating engines. The work is typical of GM Research's effort to provide useful information for a moving America. And in this way continue to keep our promise of "More and better things for more people."

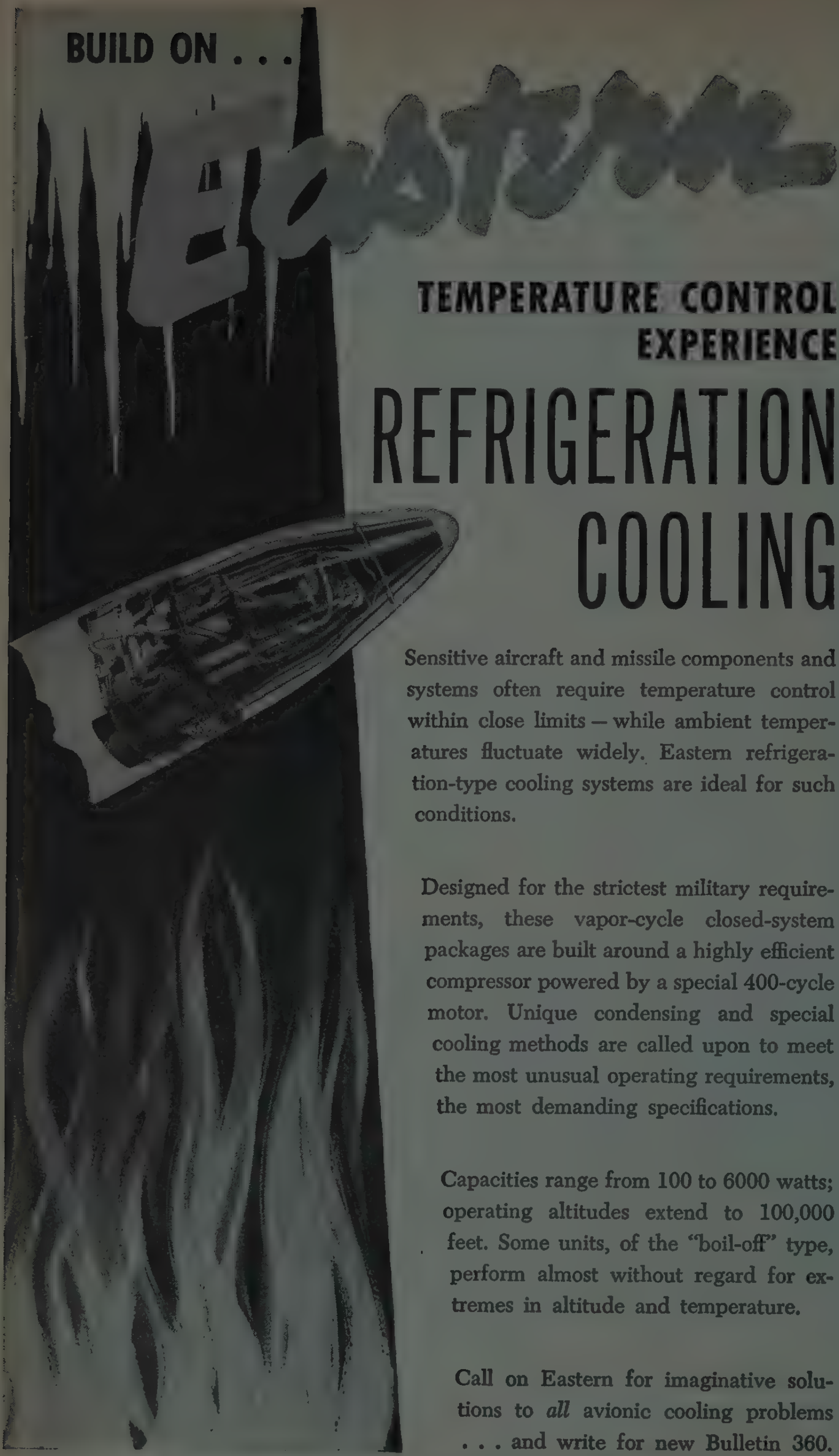
General Motors Research Laboratories
Warren, Michigan

Iron carbonyl, an antiknock

Ethyl nitrate, a proknock

Iron carbonyl retards, ethyl nitrate accelerates central portion of cool flames.

BUILD ON . . .



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REFRIGERATION
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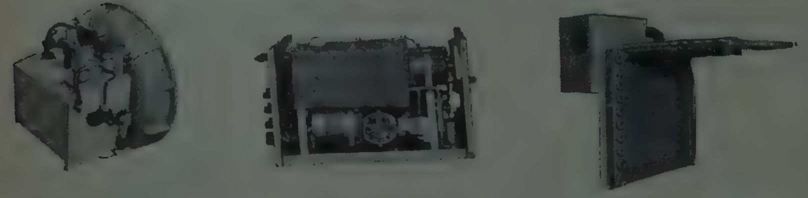
Sensitive aircraft and missile components and systems often require temperature control within close limits — while ambient temperatures fluctuate widely. Eastern refrigeration-type cooling systems are ideal for such conditions.

Designed for the strictest military requirements, these vapor-cycle closed-system packages are built around a highly efficient compressor powered by a special 400-cycle motor. Unique condensing and special cooling methods are called upon to meet the most unusual operating requirements, the most demanding specifications.

Capacities range from 100 to 6000 watts; operating altitudes extend to 100,000 feet. Some units, of the "boil-off" type, perform almost without regard for extremes in altitude and temperature.

Call on Eastern for imaginative solutions to *all* avionic cooling problems . . . and write for new Bulletin 360.



other refrigeration units for aircraft and missile electronics

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EASTERN AVIATION PRODUCTS

IRE People

(Continued from page 54A)

/ASD-1 System and 117L Subsystem.

Dr. Fubini obtained his Doctor of Physics degree in Rome, Italy. A former Lecturer of Harvard University, he has received the Presidential Certificate of Merit. He is the author of about thirty technical publications and holds eleven patents. He is a member of the Air Force Scientific Advisory Board, chairman of the Advisory Group on Electronic Warfare of the Department of Defense, member of the Advisory Group on Special Projects of the Department of Defense, chairman of the Electromagnetic Warfare Advisory Group of the Air Research and Development Command, member of a panel of the Scientific Advisory Committee to President Eisenhower, member of a panel of the National Security Agency Scientific Advisory Board, and member of the Advisory Council for the Advancement of Scientific Research and development in New York State.

❖

Floyd M. Gardner (S'49–A'54–SM'58) has announced the formation of Gardner Research Company. The new firm will provide electronics consulting services to government and industry and will be located at 9881 Nichols, Orange, Calif. Dr. Gardner was formerly associate director of Research at Interstate Electronics Corporation.

❖

R. J. GILSON

Appointment of **Robert J. Gilson** (SM'55) as director of systems management in Stromberg-Carlson's Electronics Division has been announced by Kenneth M. Lord, vice president and general manager of the division. Stromberg-Carlson is a division of General Dynamics Corp.

Mr. Gilson comes to Stromberg-Carlson from the Hoffman Laboratories Division of Hoffman Electronics Corp., Los Angeles, Calif., where he was program director for the "Tall Tom" airborne reconnaissance system. Prior to his association with the Hoffman company Mr. Gilson was with Litton Industries, in Beverly Hills, Calif., for over two years, and earlier, with the Sylvania Electronic Defense Laboratory in Mountain View, Calif.

A native of Palo Alto, Calif., Mr. Gilson received the B.S. degree in electrical engineering from Montana State College, and the M.S. degree in engineering administration from the University of California at Los Angeles. During World War II he served as a radio officer in the Maritime Service. He is a member of the American Institute of Electrical Engineers, the

(Continued on page 58A)

Umbilical

The MSC-built Umbilical Launching Cable...an example of the product diversity of Missile Systems Corporation. Like all products that bear the MSC label, this system has proven its reliability. Just as it is a life-line to the success of a mission, so also are MSC's contributions material to the future accomplishments of *all* facets of the electronic industry. MSC's variety of products form one continual life-line...feeding an industry which is already changing the life patterns of generations to come.

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Corporation of Texas/subsidiary
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TERMINAL PANELS
Complete equipment for
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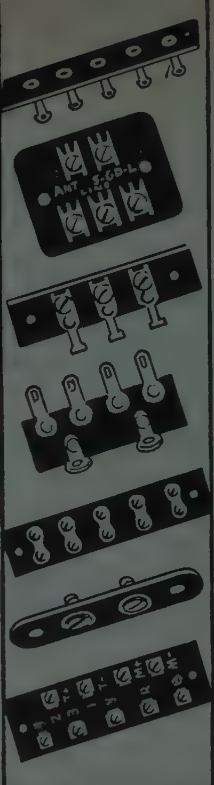

Several pages of Jones Catalog No. 22 illustrate standard and special panels we are constantly producing. Latest special equipment enables us promptly to produce practically any panel required. Send print or description for prices, without obligation. Hundreds of standard terminal strips also listed.

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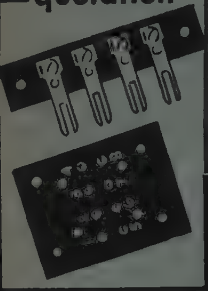
Send your specifications for prompt quotation



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Transistorized Amplifier Series T-330

A new series of completely transistorized I-F amplifiers offered to fill the need for standardized, high quality units. These T-330 series amplifiers by I.F.I. are available in a variety of center frequencies and bandwidths. They also can be equipped with emitter follower, cathode detector or low noise tube input.

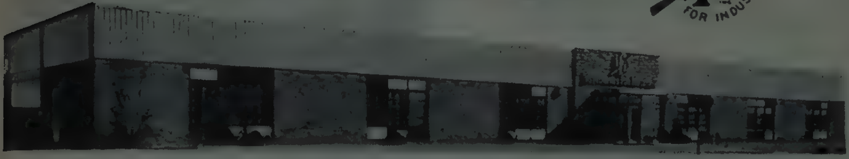
The quality of construction is high. The use of printed circuitry and quality control procedures provide rigid standards. Individual inspection and testing of each unit prior to delivery assure the superior quality of IFI transistorized I-F amplifiers. These transistorized amplifiers meet all applicable military environmental specifications.

Quantity	Unit Price
1-10	$800
11-25	700

SPECIFICATIONS

Center Freq.	T-330A	30 mc
	T-330B	30 mc
Bandwidth	T-330A	10 mc
	T-330B	3 mc
Gain	T-330A	80 db min.
	T-330B	100 db min.
Output (max)	T-330A	+5 DBM
	T-330B	+10 DBM
Input Impedance	T-330A	50 ohm
	T-330B	50 ohm
Noise Figure	T-330A	10 db
	T-330B	8 db
Mean Stage Gain	T-330A	11.5 DB
	T-330B	14.0 DB

INSTRUMENTS FOR INDUSTRY, Inc.
101 New South Road, Hicksville, L. I., N.Y.



Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New York.

See us at the IRE Show—Booth 1424

(*Continued from page 56A*)

American Management Association, the American Institute of Management and the Association of the U. S. Army.

❖

Dr. John L. Grigsby (SM'56) has joined the Palo Alto advanced electronic systems firm of Applied Technology, Inc., as Chief Engineer.

He will direct the company's expanding engineering activities in reconnaissance receiving systems, active electronic countermeasures and special instrumentation for ionosphere and radio astronomy studies.

Formerly Dr. Grigsby was with the Stanford University Applied Electronics Laboratory, since 1952 serving successively as engineer, project engineer and group leader. He also served as a consultant to several electronic firms and was a member of a special advisory committee to the U. S. Army.

In his new association he will continue his work in the application of traveling-wave and related beam tubes in broadband countermeasures and receiving systems. This has been his principal work with the Stanford laboratory.

Previously with the General Electric Company from 1949 to 1952, he instructed military personnel and GE field service engineers in theory and operation of fire-control, long-range search and height-finding radars.

During World War II he served for two and a half years with the U. S. Air Force, mostly in electronics and radar work.

Dr. Grigsby received the B.S. degree in electrical engineering from the University of Colorado in 1948. Stanford University awarded him the M.S. and Ph.D. degrees in the same field in 1955 and 1959, respectively.

He is a member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi and Sigma Tau.

❖

JOHN E. HOGG

The appointment of **John E. Hogg** (S'39–A'42–M'46) as manager of marketing administration and personnel development for the General Electric Company's Computer Department has been announced by G. A. Hagerty, Department manager of marketing.

Mr. Hogg was formerly western regional manager for the Department at Palo Alto, Calif. He will transfer to Department headquarters in Phoenix, Ariz.

In his new position, he will be responsible for all phases of product availability and delivery, including contracts administration and marketing office management,

(*Continued on page 62A*)

SSPI

NOW . . .
IN MINIATURE

SILICON CONTROLLED RECTIFIERS

actual size

FROM SOLID STATE

For control circuit application in the 10 to 1250 ma output current range

- **HIGH SENSITIVITY**
  only 2 mA input to control one ampere (continuous) at 100°C.
- **HIGH TEMPERATURE**
  stable operation to 150°C.
- **LOW LEAKAGE**
  10 uA cutoff current at full voltage.
- **SIMPLIFIED MOUNTING**
  no need for insulating hardware — stud is electrically isolated.

Type	Maximum Anode Voltage (DC or Peak AC) ± Volts	Maximum Average Forward Current 100°C Case Amps	Maximum Gate Current to "Fire" mA	Gate Voltage to Fire + Volts	
				Min.	Max.
3B30S	30	1.0	2	.40	2.5
3B60S	60	1.0	2	.40	2.5
3B100S	100	1.0	2	.40	2.5
3B150S	150	1.0	2	.40	2.5
3B200S	200	1.0	2	.40	2.5

These devices offer significant circuit advantages in that they are specifically designed for operation in the 10 to 1250 mA current range. It is no longer necessary to derate higher power units, with attendant losses in efficiency.

The miniature SCR combines a current rating of 1 ampere at 100°C with extremely small size. It features high peak recurrent and surge current ratings. Switching efficiency up to 98% is practical. High gain, low loss control of loads up to 300 watts can now be achieved along with significant miniaturization. The internally insulated junction eliminates the need for external mica washers. Assembly is therefore simplified and reliability improved.

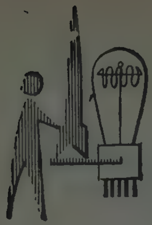
The miniature SCR is useful in applications such as AC and DC static switching, proportioning control, D.C. to D.C. converters, servo motor driving, squib firing, protective circuits, and related applications.

Encapsulated in the unique SSPI cold welded copper case, the SCR offers a high degree of mechanical ruggedness and long term reliability.

WRITE FOR BULLETIN C415-01

SOLID STATE Products, Inc.
ONE PINGREE STREET • SALEM, MASSACHUSETTS

On display at
IRE
Booth 1519 B

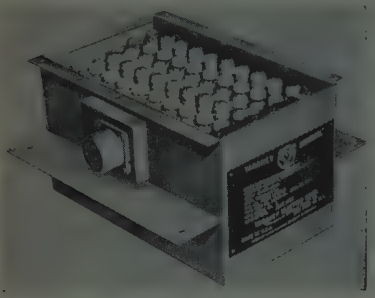


NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

Missile Battery

Development of the Silvercel battery 3381R-2 for missile applications has been announced by **Yardney Electric Corp.,** 40–50 Leonard St., New York, N. Y., manufacturer of silver-zinc and silver-cadmium batteries.



A rechargeable silver-zinc power pack, this 10-ampere-hour unit has a nominal voltage of 28 volts when discharging at 45 amperes in 12 minutes. It can also be discharged at 60 amperes, or at lower rates. It has a volume of 239 cubic inches and weighs 15 pounds. Its dry shelf life is a minimum of two years.

Designed to meet requirements for missile electric power systems, the new battery has met test specifications of MIL E5272: up to 5 G's vibration; 15 G's, 11 milliseconds in all directions mechanical shock; −65°F low temperature; 160°F high temperature; 95% humidity at 160°F; 55,000 feet at 80°F high altitude.

16 Channel Recorder

Originally designed to verify magnetic tapes in machine tool numerical control systems, the new multichannel recorders, a product of **Epsco,** a **Division of Epsco Incorporated,** 207 Main St., Worcester 8, Mass., also find industrial uses.

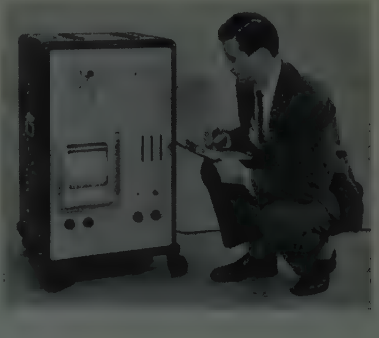
Through minor modification of existing equipment, the firm has been able to satisfy any graphic recording problems requiring more than eight channels on a common time basis.

Modular construction offers the maximum in versatility. Interchangeable preamplifiers and drivers permit rapid and economical change-over from one test to another.

The firm presently stocks five modular pre-amplifiers, low gain dc, moderate gain dc, high gain dc, ac, and carrier. Epsco's three stage differential input-output driver amplifiers are designed to supply driving power, frequency compensation and overload protection in damping impedance to the galvanometers. The ink or electric-writing galvanometers write on either standard roll chart or Epsco "Z" fold paper, and are housed in recorder cabinets equipped with nine selectable chart speeds.

Atmospheric-Particle Monitor

A new atmospheric-particle counting instrument has been designed for application by **Royco Instruments, Inc.,** 365 San Antonio Rd., Mountain View, Calif., to the continuous monitoring of outdoor air or atmospheres of indoor locations, such as ultra-clean work areas. It presents, on a stripchart recorder, a permanent record of aerosols present in an overall range from 0.3 microns to any desired upper limit. This record is differentiated into 15 subranges and recorded in sequence at intervals which can be predetermined in length. Stability problems are eliminated by the fact that the unit is continuously self-calibrated.



Included in the instrument is an alarm system which can be set for a remote indication of particle concentrations in any of the monitored sub-ranges exceeding a predetermined maximum.

Counting rate of the PC-200 is 1000 particles per minute with a 1 per cent coincidence loss at the standard flow rate of 100 cc per minute. Recordings are made on a 6-inch strip chart at a standard movement of 8 inches per hour. Operation is from a 115v 60cps supply with a current of 3 amperes.

Weighing approximately 150 lb, the unit is 21 by 19 by 32 inches overall. It is mounted on greaseless, dustless casters. Price $6,975 f.o.b. Mountain View.

Precision Phase Detector

A new precision phase measuring instrument from 15 mc to 400 mc has been developed to meet the need of measuring phase shift of radar IF amplifiers, transmission networks and radar tracking systems by **Ad-Yu Electronics Lab., Inc.,** 249 Terhune Ave., Passaic, N. J. This instrument utilizes a comparison method to achieve the accuracy of ±0.05° or ±1%. The sensitivity has been increased with the use of balanced tuned amplifiers. In addition, balanced tuned amplifiers can also minimize the error due to harmonic contents and noise.

The accuracy is ±0.05° or ±1% of the dial reading. The resolution time is less than 0.1 micromicrosecond; the smallest phase angle which can be read on the dial is less than $10^{-13} \times 360 \times$ frequency in cps. The time delay of the continuously variable delay line can be adjusted from 0 to 2.8 millimicroseconds. Two step variable delay lines have total delay of 37.5 millimicroseconds in E_1 channel and 7.5 millimicroseconds in E_2 channel (in steps of 1 millimicrosecond). The minimum input signal depends on the sensitivity of the receiver; approximately 20 microvolts for receiver having 5-microvolt sensitivity, and approximately 2 volts minimum is recommended for using panel meter as indicator. The characteristic impedance is 50 ohms nominal for both input and output; type N connectors are used throughout.

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 8

NEW RAYTHEON HEATERLESS AMPLITRONS EXCEED 1,000 HOURS AT RATED POWER OUTPUT

Two new 3-megawatt, S-band Amplitrons have demonstrated an operating life of more than 1,000 hours at rated power output. The QK-622 covers the 2,900 to 3,100 Mc band; the QK-783, the 2,700 to 2,900 Mc band. Both tubes supply full power with low phase pushing characteristics over their entire operating bands at efficiencies greater than 70%--making them unquestionably the most highly efficient microwave tubes thus far developed.

Tubes may be operated at reduced peak power levels to serve as driver stages. High efficiencies are retained at peak power of 600 Kw and gain of 10 db.

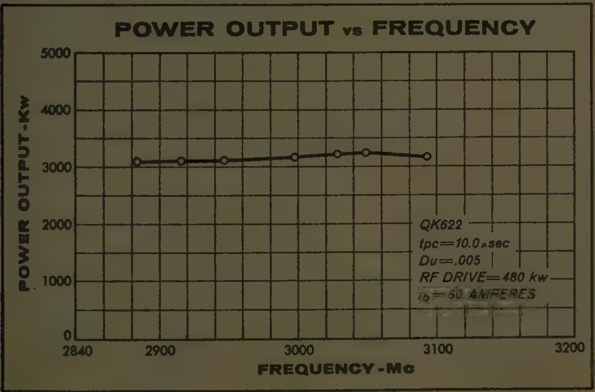
Exceptionally long tube life is made possible by the fact that no cathode warmup is required. Starting takes place whenever RF input is present prior to application of modulating pulse. Heater supplies may be omitted entirely from the equipment.

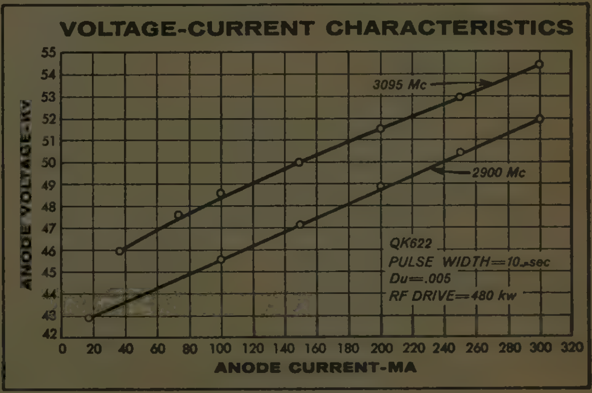
Applications include power-amplifier stages for long-range radars. The tube has been used successfully as an RF power source for linear accelerators.

QK-622 Amplitron

Typical Operating Characteristics
(QK622 and QK783 Amplitrons)

Peak Power Output (min.)............	3 Mw
Average Power Output...............	15 Kw
Pulse Duration	10 μ sec
Band Width	200 Mc
Duty Cycle	.005
Pulse Voltage	50-55 Kv
Peak Anode Current	65 amps
Efficiency.........................	70%
RF Input	475 Kw
Weight (with permanent magnet)	125 lbs.





You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts

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RAYTHEON

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AN EAR TO THE SKY
AN EYE ON . . .
Booths 3826-28
I.R.E. SHOW
NEW YORK COLISEUM
MARCH 21-24
FOR THE NEWEST IN
TELEMETERING and COMMUNICATION EQUIPMENT from NEMS-CLARKE CO.

1906 RECEIVER

Tuning Range .... 30-260mc (two bands: 30-60mc, 60-260mc switched)
Noise Figure .... 6db maximum
Input Impedance .... 50 ohms unbalanced to Type N connector on rear apron
IF Rejection .... 65db minimum
Image Rejection .... 60db minimum
IF 21.4mc
IF Bandwidths: 300kc, 20kc (switchable from front panel)
Power Input: 115/230v AC, 50/60 cycles, 100w approx.
Size ..... 19" wide, 3½" high, 15" maximum depth

NEMS·CLARKE CO.
A DIVISION OF VITRO CORPORATION OF AMERICA
919 JESUP-BLAIR DRIVE
SILVER SPRING
MARYLAND
PRECISION ELECTRONICS SINCE 1909

(Continued from page 58A)

and for educational and training programs for marketing personnel.

A native of Vancouver, Wash., he received the B.S. degree in electrical engineering from the University of Washington in 1940. Shortly thereafter, he joined General Electric's Test Program at Schenectady, N. Y., as a student engineer. He subsequently served in various engineering and sales assignments throughout the Company and in 1956 was appointed Pacific regional manager for the Computer Department. He has also worked as a sales engineer for William Miller Instrument Company, manager of field sales for AMPEX Instrument Division, and manager of marketing for AMPEX International.

Mr. Hogg is a member of the Instrument Society of America, Tau Beta Pi, and Sigma Xi.

❖

R. C. HANSEN

Dr. Robert C. Hansen (S'47–A'49–M'55–SM'56) has been appointed Senior Staff Engineer in the Telecommunications Laboratory of the Space Technology Laboratories of Los Angeles, Calif. Prior to this, he was a Senior Staff Engineer in the Hughes Microwave Laboratory.

He obtained the B.S. degree from the Missouri School of Mines and Metallurgy and the Ph.D. degree from the University of Illinois. He has been active in IRE affairs, having been PG coordinator for the Los Angeles Section and Chairman of the WESCON Technical Program Committee. He is currently a member of the PGAP and PGMTT Administrative Committees, and is Western Vice Chairman of the Professional Groups Committee.

Dr. Hansen is a member of the American Physical Society, Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and Phi Kappa Phi.

❖

P. S. HESSINGER

Philip S. Hessinger (SM'39) has been named Manager of Research of National Beryllia Corporation, North Bergen, N. J., according to an announcement by Christian E. Nelson, President. In the newly-created position, he will be associated with Dr. Eugene Ryshkewich, National Beryllia's Director of Research, in administration of the company's expanded program of research and development relating to be-

(Continued on page 64A)

High voltages at high power. Tricky business—but a specialty of the Carad Corporation. Take this 30 kv, 3.3 ampere DC power supply, for instance. Carad designed and built this one in 70 days for Eitel-McCullough, Inc. It supplies beam voltage for production testing of high-power klystrons—80 to 100 hours a week. One important characteristic is its ability to withstand severe load arcing—and protect the klystron being tested. This Carad supply will clear itself in 30 to 50 milliseconds and includes special reactors to limit current surges. For custom systems involving high-voltage supplies, pulsers, modulators or special transformers, investigate Carad's unusual capabilities.

CARAD CORPORATION

2850 Bay Road • Redwood City • California

DESIGNERS AND MANUFACTURERS OF
SYSTEMS AND PULSE COMPONENTS

NEW . . . 1¾-inch slide . . . saves space
2 NEW Chassis-Trak Slides
NEW . . . lightweight, extra-thin slide

Engineering progress at Chassis-Trak, keeping pace with the equipment mounting needs of the electronics industry, has resulted in two new slide designs. They are:

1¾-inch slide

Ideal for light-duty slide applications—loads up to 50 lbs. Chassis-Trak "pencil thin" design plus an overall height of only 1.687" saves cabinet space, permits easy mounting without cabinet modification. Cadmium-plated cold-rolled steel construction. Phenol epoxy coating provides permanent dry lubrication. Tilt and non-tilt styles in eight standard lengths—10, 12, 14, 16, 18, 20, 22 and 24 inches.

Lightweight slide

Newly developed model for special equipment mounting problems. Exceptionally compact (1" high, ½" wide), yet supports up to 150-lb. loads. Saves space without sacrificing heavy-duty strength. Low in cost, easy to install. All stainless steel construction. Precision roller and ball bearings for effortless operation.

Check with Chassis-Trak engineers for the solution to your rack or cabinet application. Slides available in tilt, non-tilt, and tilt-lock models. Supports up to 275 lbs.

For further information contact:

chassis Trak inc.

525 S. Webster, Indianapolis 19, Indiana

(*Continued from page 62A*)

ryllium oxide and other pure metal oxide ceramics.

He was formerly employed at the Mycalex Corporation of America, where he was Acting Director, Research and Development. He has also engaged in and directed ceramics research at Ohio State University Research Foundation and Wright Air Development Center.

Mr. Hessinger is a member of the American Ceramic Society, the National Institute of Ceramic Engineers, and the American Society for Testing Materials. He is the author of many papers and articles on ceramics, and is chairman of the ASTM group on measurement of ceramic insulation value at elevated temperatures. He holds the B.S. and M.S. degrees in Ceramic Engineering from Alfred University and Ohio State University.

❖

Dr. Harold K. Hughes (A'36–M'46) has been appointed director of the Department of Physics at the Central Research and Engineering Division of Continental Can Company in Chicago, it was announced by Curtis E. Maier, general manager of the Division.

H. K. HUGHES

He will head the company's research work on application of the principles of physics to high speed automatic equipment for the production and quality control of metal, paper, plastic, glass and composite containers and closures, and for any future radiation program. His experience is in the fields of physics and instrumentation and includes work in electronics, radio frequency spectroscopy, molecular beams, applied spectrochemical analysis, X-ray diffraction analysis and statistics.

From 1945 to 1958, Dr. Hughes held positions in the fields of applied physics with the Celanese Corporation of America, Socony-Mobil Oil Co. and the Markite Corporation. During the years 1935 to 1945, he was in the academic world as assistant professor and head of the Physics Department of the University of Newark, instructor in Physics at Columbia University and scientist at the Columbia Radiation Laboratory.

Dr. Hughes received the B.A., M.S., and Ph.D. degrees from Columbia University. He is a member of the American Physical Society, the American Chemical Society, the American Society for Quality Control, the Society of Applied Spectroscopy, the Electro chemical Society and other professional groups.

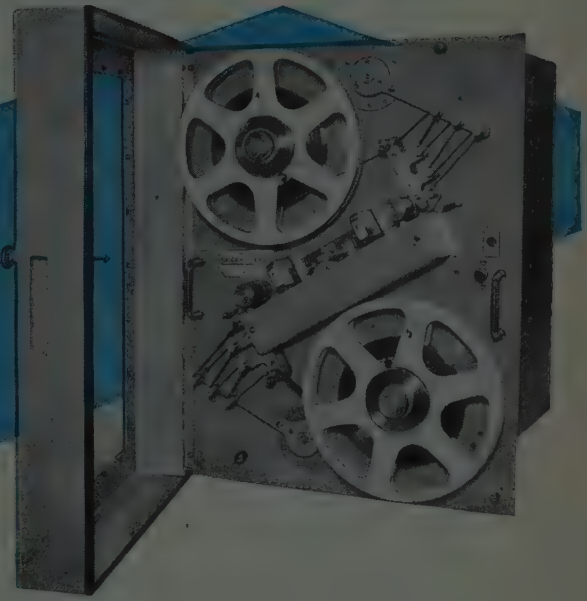
❖

(*Continued on page 66A*)

ONE OF MANY EXAMPLES
OF EXCELLENCE IN THE DATA
HANDLING FIELD

Cook Electric Company's *New*
DIGITAL TAPE TRANSPORT

SOLID STATE
ULTRA RELIABLE
HIGH PERFORMANCE
MILITARY QUALITY



The Data-Stor Model 59 Digital Tape Transport is ideally suited for use in computer, instrumentation and control applications. It incorporates the highly reliable features of military tape transports developed by Cook Electric Company during the past 12 years, and has been proven in the Atlas, Titan, Polaris and other missile programs.

These features include exclusive use of modern ultra reliable solid state circuitry, eliminating gas or vacuum tubes. Precise tape handling is insured by proportional reel drive servo systems that have no jerky step servos. Tension error sensing is accomplished by synchro transmitters with no unreliable potentiometers or contact pile-ups. Field adjustments are eliminated by building tolerances into a single rugged tape deck casting. Endurance and quality are assured by strict adherence to the exacting design and workmanship requirements of MIL-E-4158.

TAPE SPEEDS TO 150 IPS • LESS THAN 3 MS STOP/START • REWIND SPEEDS TO 400 IPS • NO PROGRAMMING RESTRICTIONS • PACKING DENSITIES TO 600 NRZ BPI • OPERATES FROM 5 VOLT CONTROL PULSES OR LEVELS OF EITHER POLARITY • FRONT PANEL ACCESS • CHOICE OF NARTB, IBM, OR SPECIAL REELS • ANY TAPE TO 1" • CONDUCTIVE LEADER, LIGHT TRANSMISSIVE, OR LIGHT REFLECTIVE END OF TAPE SENSORS • SOLID STATE READ/WRITE AMPLIFIERS • METAL FACED READ/WRITE MAGNETIC HEADS • AVAILABLE AS HIGH SPEED PHOTOELECTRIC READER.

Experienced recording systems engineers are invited to apply for existing employment opportunities.

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A DIVISION OF
Cook Electric Company

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MINIATURE TRANSISTOR TRANSFORMERS

from stock

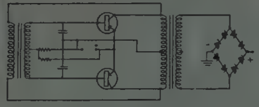
miniaturized
transformers

Design and performance meets or exceeds all applicable commercial and government specifications including MIL-T-27A. Available for immediate delivery from Franchise Stocking Distributors.

DC-DC CONVERTER

All Items Designed for 13.6V. Except 8034 which is for 28V Input.

TYPICAL DC-DC CONVERTER CIRCUIT



Part Number	Total V.A. Output	D.C. Output F. W. Bridge Volts	Ma.	C.T. Full Wave Volts	Ma.
M8034	125	500	250	250	420
M8035	125	500	250	250	420
M8036	40	450	90	225	155
M8037	22.5	250	90	125	155

MICRO MINIATURE TRANSISTOR

Available in 4 case types
Hermetic (-H) 15/16" x 11/16", wt. ¾ oz.
Open Frame (-F) 7/16" x 19/32" x ¾", wgt. .4 oz.

Part Number	Application	Pri. Imp.	Sec. Imp.
MMT 5*	Coll. to Speaker	50,000	6
MMT 7*	Coll. to P.P. Emit.	25,000	1,200 C.T.
MMT 9*	Line to P.P. Emit.	600 C.T.	1,200 C.T.
MMT 10*	Coll. to Emit.	25,000	600
MMT 11*	P.P. Coll. to Emit or Line	4,000 C.T.	600 C.T.
MMT 12*	Coll. to Speaker	2,000	3.4
MMT 16*	Coll. to P.P. Emit.	10,000	1,500 C.T.
MMT 17*	P.P. Coll. to P.P. Emit.	10,000 C.T.	200 C.T.
MMT 18*	P.P. Coll. to P.P. Emit.	25,000 C.T.	1,200 C.T.
MMT 19*	Coll. to P.P. Emit.	2,500	2,500 C.T.

*Add either -M or -H to part number to designate construction. See catalog for detailed information.

ULTRA MINIATURE TRANSISTOR

NEW

Open-frame (-F)* Wt. .08 oz. size 3/8 [illegible] 3/8" x 11/32"
Molded (-M)* Wt. .14 oz. size [illegible] x [illegible]" dia.
Nylon Bobbin, Nickel Alloy [illegible]

Part Number	Application	Primary Impedance [illegible]	Secondary Impedance
UM 21*	[illegible]	[illegible]	1,000
UM 22*	Driver	[illegible]	1,000
UM 23*	Driver	20,000	1,200 C.T.
UM 24*	Output	1,000	50
UM 25*	Output	400	50
UM 26*	Output	400	11
UM 27*	Output	400 C.T.	11
UM 28*	Choke	10 Hy. (0 dc)	8 Hy (.5 ma) 650

*Add either -F or -M to designate construction. See catalog.

Write TODAY for catalog and price list of the complete MICROTRAN line.

MICROTRAN company, inc.
145 E. Mineola Ave., Valley Stream, N.Y.

IRE People

(Continued from page 64A)

Raymond F. Guy (A'25–M'31–F'39) Senior Staff Engineer of the National Broadcasting Company, has been elected President of the De Forest Pioneers.

He is a pioneer in radio, television and short wave broadcasting. He was a combined announcer and engineer and a well-known air personality in the earliest days of broadcasting in the New York area. For nearly 30 years he was responsible for planning and construction of all NBC transmitting facilities, which included a leading part in the creation of the pioneering Empire State Building TV tower which is shared by all New York stations.

Mr. Guy is a Past President of the IRE, a Fellow of the American Institute of Electrical Engineers, a Past President of the Broadcast Pioneers, and First Vice President of the Veteran Wireless Operators Association, an organization of prominent industry veterans of the very early days of wireless. He is Chairman of the Engineering Committee of the Voice of America, for many years was Chairman of the Engineering Committee of the Television Broadcasting Association and the Engineering Advisory Committee of the National Association of Broadcasters, and is active in many other organizations, several of which have honored him with medals of achievement and special citations

(Continued on page 68A)

CAPITOL RADIO ENGINEERING INSTITUTE

Advanced Home Study and Residence Courses in Electronics, Automation and Industrial Electronics Engineering Technology

Pioneer in Electronics Engineering Instruction Since 1927

ECPD Accredited
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STAMPED VINYL PLASTIC SLEEVING
LAMINATED SNAP-ON SPLIT SLEEVES
STAMPED SILICONE RUBBER SLEEVING

Permatag wire markers are furnished in bulk or carded in sequence according to blue prints or wiring diagrams.

Phone or write for samples and quotations.

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Electronic Lacing Cords to Mil-T-713A
Mil-C-5649B

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PRECISION PRODUCTS DIVISION
CHICAGO, ILLINOIS

C·D·I

UNIQUE ROTARY SWITCH

Rare Combination: *RELIABILITY *FLEXIBILITY *SERVICEABILITY

ESENTLY SUPPLIED FOR CRITICAL MILITARY APPLICATIONS

l for any application requiring high reliability. Can be furnished to
: applicable requirements of MIL-S-3786 and MIL-E-5272.

Unusual Flexibility

- Quick program changing.
- Quick configuration changing.
- Quick circuit changing.

5-SECOND WAFER REPLACEMENT

Here's all you do:

Turn Dial to Top Position and withdraw dust cover.

Snap out old wafer, snap in replacement wafer, restore dust cover.

Servicing is finished in seconds. No time-wasting disassembling, wire removing or soldering. No skilled technicians needed for wafer changing.

OTHER FEATURES

- All connections on one side for easy access and wiring.
- Lower torque than most standard switches.

Manually, motor or solenoid operated rotary switches are available in sizes approx. 2″ x 2″, 3″ x 3″ and 4″ x 4″ with lengths to accommodate up to 36 wafers. Virtually unlimited choice of switch circuit configurations. Manufactured under U. S. Patent No. 2,841,660. Other U. S. and foreign patents pending. Write today for technical literature.

C·D·I

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PRECISION PRODUCTS DIVISION
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CORNING GLASS 7052
RODAR
THERMAL EXPANSION OF RODAR
EXPANSION — MILS PER INCH
3.0
2.0
1.0
0
30 86
100 212
200 392
300 572
400 752
500 932
°C °F
TEMPERATURE
TOPHET

THE *Specialized* ALLOY
FOR GLASS HERMETIC SEALS

RODAR®

...ASSURES *Permanently-Bonded* VACUUM-TIGHT SEALS!

Another Special Alloy for a Specific Purpose

This precision alloy was developed for sealing metal to hard glass. Wilbur B. Driver Rodar is processed from melting to finished size in our own plant under the strictest controls to insure consistent analysis, temper, uniform grain size and conformance to customers' specifications. The superior stamping and sealing properties of Rodar make it *the preferred sealing alloy.*

Rodar produces a permanent, vacuum-tight seal with simple oxidation procedure and resists attack by mercury. Readily machined and fabricated, Rodar can be welded, soldered or brazed. Available in wire, strip and bar to your specifications.

PROPERTIES
Composition (Nominal)
Nickel 29%
Cobalt 17%
Manganese . . .30%
Iron . . . . . . Balance
Melting Point . . 1450°C. (Approx.)
Specific Gravity. . 8.36
Weight Per Cubic Inch . . . . .302 lb.
Electrical Resistivity . . . 294 Ohms C.M.F.
Tensile Strength . . . . . . 80,000 PSI
Hardness . . . . 82 B Rockwell
Elongation 30% (2" gauge length)

VISIT BOOTHS 4201-4203 IRE SHOW!

Temperature Range	Average Thermal Expansion, *Cm/Cm/°Cx10-6
30° To 200 C.	4.33 To 5.30
30° To 300 C.	4.41 To 5.17
30° To 400 C.	4.54 To 5.08
30° To 450 C.	5.03 To 5.37
30° To 500 C.	5.71 To 6.21

*As determined from cooling curves, after annealing in hydrogen for one hour at 900°C. and for 15 minutes at 1100°C.

WILBUR B. DRIVER CO.
NEWARK 4, NEW JERSEY

IN CANADA: Canadian Wilbur B. Driver Company, Ltd., 50 Ronson Drive, Rexdale (Toronto)

IRE People

(Continued from page 66A)

Dr. Robert R. Johnson (S'50–M'56) will be responsible for engineering design and development of the General Electric Company's Computer Department's complete line of computers and computing systems. A native of Madison, Wis., he joined General Electric in 1950 as a test engineer at Schenectady, N. Y., following graduation from the University of Wisconsin with the B.S. degree in Electrical Engineering. He received the Master's degree from Yale University in 1951, specializing in servomechanisms, and in 1955 was awarded the Ph.D. degree in electrical engineering at California Institute of Technology.

R. R. Johnson

Dr. Johnson has been awarded several patents and has written chapters for two computer handbooks. He is a member of the American Institute of Electrical Engineers.

❖

David Y. Keim (A'36–VA'39–M'55) has been appointed director of engineering in Stromberg-Carlson's Electronics Division has been announced by Kenneth M. Lord, vice president and general manager. Stromberg-Carlson is a division of General Dynamics Corporation.

In his new position he will be responsible for the administration of design and development engineering work in the division.

D. Y. Keim

He joined Stromberg-Carlson in March, 1959, as chief engineer of military products in the Electronics Division. He previously served as engineering department head for microwave and electronic equipment and also directed advanced research work in the field of microwave devices for the Sperry Gyroscope Company. Earlier he was employed by Sylvania Products Company.

Mr. Keim received the B.S.E.E. degree from Pennsylvania State University in 1936. He is a member of the American Institute of Electrical Engineers and the American Ordnance Association. He has contributed a number of papers on weapons support equipment and related subjects to technical journals.

❖

Dr. Robert C. Langford (M'54–SM'55) has been appointed director of engineering of the Newark Operations of Weston Instruments Division of Daystrom, Incorpo-

(Continued on page 72A)

BUSS FUSES
SLOW BLOWING

Buss and Fusetron Fuses

. . . help you safeguard your product's reputation for Quality and Reliability!

Undoubtedly, you take pride in the products your company manufacturers . . . and try to avoid using any components that could result in customer dissatisfaction . . . which in turn can affect your company's sales curve.

That's why it doesn't pay to gamble with fuses that could be faulty and create trouble for your customers — either by failing to protect and causing useless damage to equipment, or by blowing needlessly and causing unnecessary shutdowns.

With BUSS and FUSETRON fuses safe, dependable electrical protection is assured. Before one of these fuses ever leaves our plant, it is electronically tested to make sure it is right in every way . . . to make sure it will protect, not blow needlessly.

When you specify BUSS or FUSETRON fuses, you are safeguarding against customer complaints for you have equipped your product with the finest electrical protection possible. You are also helping to maintain the reputation of your product for service and reliability.

To meet all fuse requirements, there's a complete line of BUSS and FUSETRON fuses in all sizes and types . . . plus a companion line of fuse clips, blocks and holders.

For more information on BUSS and FUSETRON Small Dimension fuses and fuseholders, write for BUSS bulletin SFB.

BUSSMANN MFG. DIVISION,
McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.

759

BUSS fuses are made to protect - not to blow, needlessly.

[illegible]

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

McGRAW EDISON

See us at the IRE show—Booth #2737.

General Mills

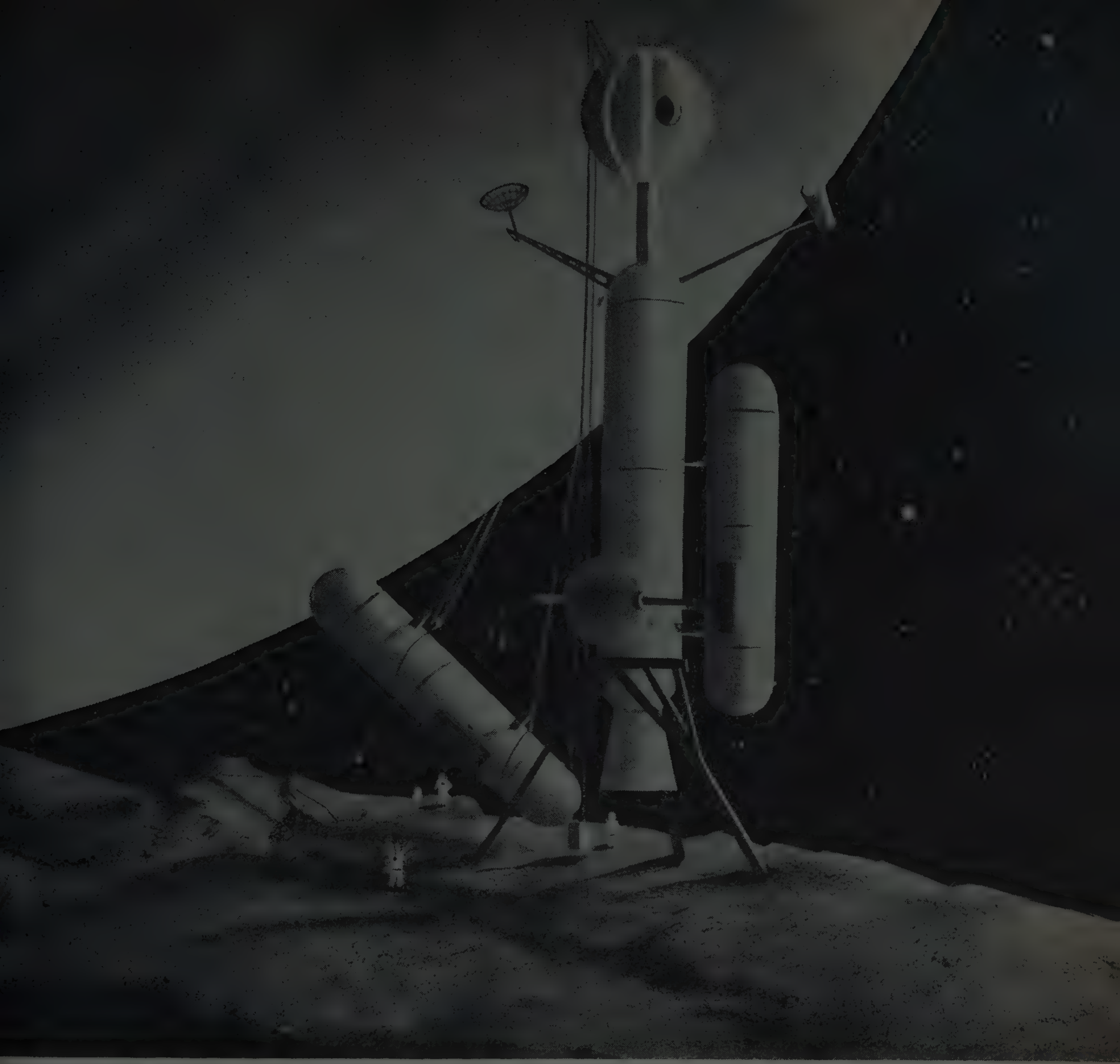
Here is Francis Alterman, Manager of General Mills Digital Computer Laboratory, checking one of our newest computers which he helped design. General Mills computers, both analog and digital, are being used in missile guidance, bombing and navigation systems, automatic surveying and in industrial control. In future space travel, computers will help control navigational systems of space vehicles and will process data gathered in outer space.

General Mills engineers work today

General Mills has been producing computers for nearly 20 years. Exciting new concepts in high speed magnetic tape units, ultra-high precision analog to digital converters and optical keyboards are examples of continuous developments in our over-all computer program. We work to improve reliability, increase speed, cut cost.

Our research activities cover broad areas in physics, chemistry, mechanics, electronics and mathematics. Some of the studies representative of these activities are: ions in vacuum, deuterium sputtering, dust erosion, magnetic materials, stress measurements, surface friction and phenomena, trajectory data and infrared surveillance.

In our engineering department, current projects include: specialized inflatable vehicles and structures, airborne early warning systems, micro wave radar test equipment,



Mars seen from one of its moons . . . illustration from book written for General Mills by Willy Ley.

to help you explore space tomorrow

antennas and pedestals, infrared and optics, inertial guidance and navigation, digital computers—and many other activities.

Our manufacturing department is geared to produce systems, sub-systems, and assemblies to stringent military requirements.

STOP AT GENERAL MILLS EXHIBIT
BOOTHS 3937, 3939

IRE SHOW

New Concepts in Computers

New York Coliseum March 21-24, 1960

MECHANICAL DIVISION

1620 Central Avenue, Minneapolis 13, Minnesota

To wider worlds—through Intensive Research • Creative Engineering • Precision Manufacturing

General Mills

NEW FROM NARDA

Model
10001
$4700.
High Power

MICROWAVE
MODULATOR

accepts over 40 magnetrons!

Here's the first of a series of new products from Narda's recently-established High Power Electronics Division! A high power Microwave Modulator that permits installation **inside the unit** of any of more than 40 magnetrons! Complete, compact and self-contained, it accepts magnetrons covering 3,200 mc to 35,000 mc, with peak outputs from 6 KW to 120 KW. Model 10001 features a completely interlocked circuit, with all high voltage leads and connections **internal**, for maximum safety; solid state high voltage bridge rectifiers for longer life and reduced heat output (prolonging life of other components, too); and built-in meters and viewing connectors for all principal parameters.

Other features are shown below. For complete specs and a list of at least 40 magnetrons suitable for use with the 10001, write Narda's High Power Electronics Division (HPED) at Dept. PIRE-7.

SPECIFICATIONS

High voltage supply: Continuously variable from 0 to 4 KV at 100 ma; **Pulse power:** 18 KV at 20 amps max.; **Magnetron filament supply:** Cont. variable from 0 to 13 volts at 3 A; **Rep. rate generator range:** Cont. variable from 180 to 3000 pps; **Pulse width:** 1 microsecond at 70% points, rise time 0.15 microseconds, max. slope 5% (other pulse widths available); **Size:** 38" h, 22" w, 18" d. **Weight:** 150 lbs.

Complete 1959 catalog available on request.

the narda microwave corporation
HIGH POWER ELECTRONICS DIVISION
118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

(Continued from page 68A)

rated. The plant is a unit in Daystrom's Industrial Products Group.

He succeeds **Francis X. Lamb** (A'36–VA'39–M'55), formerly the Newark plant's vice president of engineering, and for 30 years an outstanding figure in the development of techniques and devices for the measurement of electricity. Mr. Lamb was named engineering consultant to J. F. Degen, vice president of Operations, at Newark.

Both appointments, effective immediately, were announced by Mr. Degen, who said that Dr. Langford will be responsible for Weston-Newark's Engineering Services and Product Development.

Dr. Langford was chief engineer for Research and Development at the Newark Operation.

A native of Portsmouth, England, he obtained the B.S. degree (cum laude) in 1944 from the University of London, which he attended on the Sylvania-Thompson Scholarship awarded him by the Institute of Electrical Engineers. He was subsequently granted the Swan Research Fellowship and attained his doctorate from Queen Mary College, London.

He is a holder of several patents on instrumentation and author of many papers, including co-authorship on the subject in standard technical reference books.

Dr. Langford is a member of the American Institute of Electrical Engineers and the American Nuclear Society. He is chairman of the Instrumentation Division of the AIEE in New York. He is also chairman of the IRE Professional Group on Engineering Management of the IRE and a member of the Technical Program Committee planning the program content of the 1960 IRE Convention.

❖

In a move to expand the company's operations in advanced military and industrial electronics, Packard Bell Electronics Corp. has announced the formation of a new Defense and Industry Group, encompassing two divisions and a subsidiary.

R. B. Leng

Affected are the Technical Products Division; the Packard Bell Computer Corporation, which has been operating as a division; and Technical Industries Corporation of Pasadena, a subsidiary.

Robert S. Bell, president, said **Richard B. Leng** (SM'53), former vice president in charge of the Technical Products Division, will head the new organization as group vice president to coordinate more closely the design, engineering, development, manufacturing and marketing of electronic instruments and systems.

❖

(Continued on page 74A)

SIX VSWR AMPLIFIER FEATURES

...available only from NARDA

1. **Battery-operated (rechargeable nickel-cadmium).**
2. **Completely transistorized for low current drain.**
3. **Independent of line voltage variations.**
4. **Complete bolometer protection during switching.**
5. **Most compact unit available.**
6. **Completely portable.**

Model 441B—$225

SQUARE LAW DETECTOR
the narda
microwave corporation
BATTERY CHECK
CHARGING
VSWR AMPLIFIER
NARDA MODEL 441B

Now you can get a completely portable battery-operated VSWR Amplifier offering complete protection against bolometer burnout at the same time!

Narda's Model 441B is supplied with nickel-cadmium batteries, providing complete freedom from line voltage deviations. Batteries recharge automatically when unit is plugged in; provision is built-in to show state of battery charge. A special protective circuit permits switching and connect-disconnect with no danger of bolometer burnout. Provision is made for both crystals and high and low current bolometers.

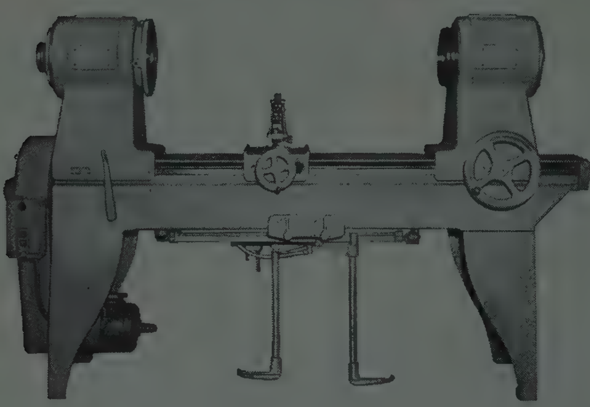
Full sensitivity is provided over both normal and expanded scales; eliminates switching attenuation range. Other features are shown on this page; for complete information and a free copy of our latest catalog, write to us at: Department PIRE-10.

FEATURES:

• **SENSITIVITY:**	0.1 microvolts at 200 ohms for full scale.
• **FREQUENCY:**	1,000 cps ± 1% (plug-in frequency networks available for 315-4,000 cps and broad-band applications)
• **BANDWIDTH:**	25-30 cps
• **RANGE:**	72 db (60 db in 10 db steps, 11 db continuous)
• **ACCURACY:**	± 0.1 db per step • ± 0.2 db maximum cumulative • meter linearity: 1% of full scale

the narda microwave corporation
118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

GLASS WORKING LATHES



NEW MODEL ESA $3200.00 NEW
Price f.o.b. Grass Valley

STANDARD EQUIPMENT

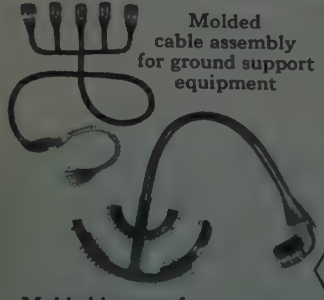
Two face plates
One collet draw-in bar
One 6-fire seven jet burner assembly
Hand carburetion control
Foot pedal control of air or nitrogen supply and of oxygen-gas volume
Main air valve controlling air in either or both spindles
½ h.p. Motor, 230 volt, three phase, single speed, 60 cycle, AC
Face plate wrench
One motor belt
One motor pulley

General Specifications
Variable Speed Drive — Electronic Control (As shown) Available at extra cost

Maximum length overall	84″	Spindle hole diameter	7¼″
Maximum width overall	24″	Radial clearance above apron	13¾″
Maximum length spindle nose to spindle nose	47″	Net weight	Approx. 1250 pounds
		Approx. shipping weight	1500 pounds

Litton Engineering Laboratories
Grass Valley, California • P. O. Box 949

ROBERTSON MOLDED HARNESSES MEAN PROTECTION



Molded cable assembly for ground support equipment

Molded harness for underwater devices

against deterioration caused by acids, oils, fuels, flame, ozone, water or moisture.

against abrasion, shock, fungi, and temperature extremes.

Robertson molded cable assemblies have been painstakingly engineered and built to the same standards of military precision and dependability as the underwater devices, missile control systems, and mobile electronic equipment for which they are designed.

Robertson Electric Co., Inc.
124 S. Elmwood Ave. • Buffalo 2, N. Y.
Established in 1895

IRE People

(Continued from page 72A)

Election of **John J. McDonald** (A'50) as a vice president of Consolidated Systems Corp., a wholly owned subsidiary of Consolidated Electrodynamics Corp., has been announced by Kennett W. Patrick, CSC president.

J. J. McDonald

He was appointed director of engineering when CSC was incorporated as a subsidiary of Consolidated Electrodynamics on March 1 of this year. He will continue at this post. Previously, he was assistant director of the Systems Division for three years and manager of CEC's Central Regional Office in Chicago for five years.

Mr. McDonald is a vice president of the Instrument Society of America and has served the ISA as a national director, director of the Transportation Industry Division, and chairman of the Research and Development Committee. He is a member of the American Institute of Electrical Engineers, Society for Experimental Stress Analysis, American Standards Association, and American Rocket Society. He received the B.S. degree in physics from the University of Chicago and the B.S. degree in electrical engineering from the Armour Institute of Technology.

❖

Dr. John C. McGregor (M'46–SM'49), president of The Narda Ultrasonics Corporation, Westbury, N. Y., has taken on the added responsibility of marketing of the wares of the firm.

J. C. McGregor

Physicist and lawyer, Dr. McGregor is also chairman of the board of the related Narda Microwave Corporation, developer of electronic items. He also is board chairman of Technical Information Corporation and of Harper and Saladino, Inc., industrial art specialists, and a director of North Atlantic Industries.

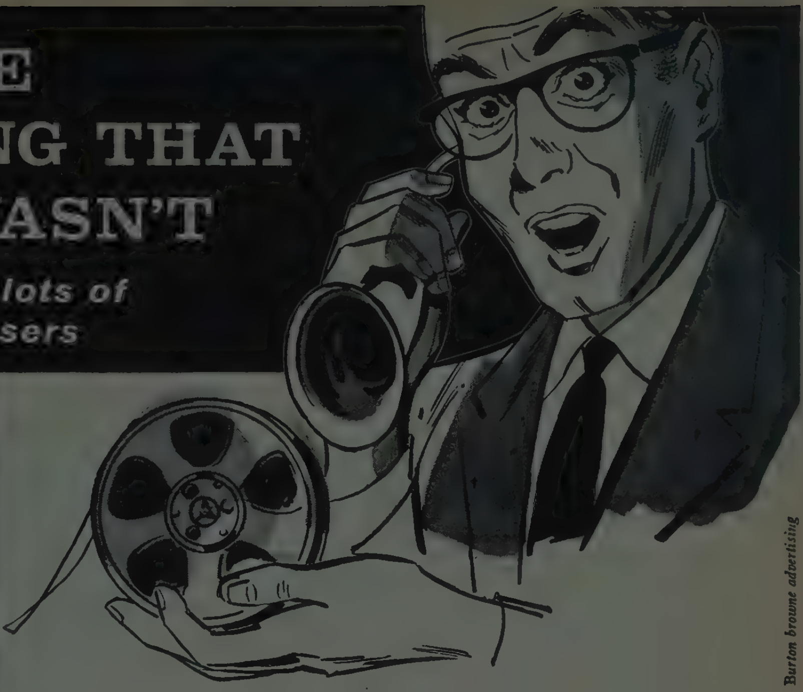
Dr. McGregor received the B.S. degree in physics from Carnegie Institute of Technology in 1941; the LL.B. from St. John's University (New York) in 1947, and the Doctorate of Jurisprudence from Brooklyn Law School in 1949. He is a member of Sigma Nu, Phi Delta Phi (legal), the Nassau County Bar Association, and the Institute of Aeronautic Sciences. He is admitted to practice in the New York State, Federal and Patent Courts.

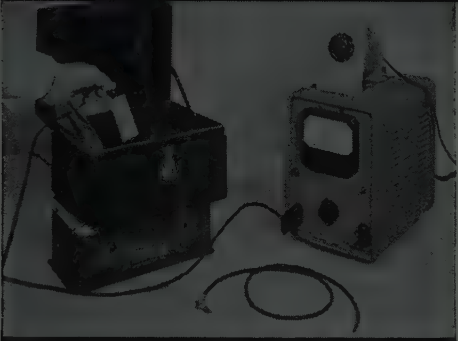
❖

(Continued on page 76A)

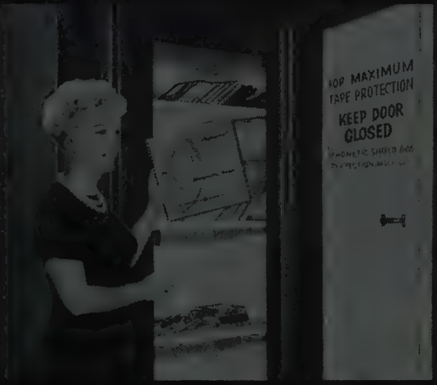
THE RECORDING THAT WASN'T

. . . It's happened to lots of magnetic tape users





Test laboratory demonstrates shielding effectiveness of Netic alloy material and enclosure design. Instrumentation used: magnetic field radiating source, AC vacuum tube voltmeter, Variac, pickup probe and Netic Tape Data Preserver. For complete test details and results, request Data Sheet 142.



For safe, distortion-free storage of large quantities of vital magnetic tapes. Designed for Military Establishments, Radio & TV Broadcasters, Automated Plants, Libraries, Laboratories, Gov't. Agencies, etc.

Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock (including dropping) etc. Furthermore, NETIC does not retain residual magnetism nor require periodic annealing.

Maybe you've been one of these unfortunates . . . who've spent thousands of dollars . . . plus many man hours . . . to record valuable information on magnetic tapes . . . only to find the data useless from accidental distortion or erasure.

Unexpected exposure to an unpredicted magnetic field, and presto!—your valuable data is filled with irritating odd noises. Distortions may result in virtual data erasure.

Unprepared tape users never realize the danger of loss until it's too late.

Such losses have become increasingly common from damaging magnetic fields during transportation or storage. These fields may be produced by airplane radar or generating equipment or other power accessories. Also by generators, power lines, power supplies, motors, transformers, welding machines, magnetic tables on surface grinders, magnetic chucks, degaussers, solenoids, etc.

Since 1956, many military and commercial tape users successfully avoid such unpleasant surprises. Their solution is shipping and storing valuable tapes in sturdy NETIC Tape Data Preservers.

Data remains clear, distinct and distortion-free in NETIC Preservers. Original recorded fidelity is permanently maintained.

Don't take chances with *your* valuable magnetic tapes. Keep them *permanently clear* and *distinct* for *every* year of their useful life in dependable NETIC Preservers. Can be supplied in virtually any size and shape to your requirement. Write for further details today.

For complete, distortion-free protection of valuable tapes during transportation or storage. Single or multiple containers available in many convenient sizes or shapes.

MAGNETIC SHIELD DIVISION PERFECTION MICA CO.

1322 No. Elston Avenue, Chicago 22, Illinois
Originators of Permanently Effective Netic Co-Netic Magnetic Shielding

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NOWHERE IN THE WORLD WILL YOU FIND SUCH A VARIETY OF FASTENERS UNDER ONE ROOF

EYELETS, RIVETS, GROMMETS, WASHERS, HOLE PLUGS SNAP FASTENERS, FERRULES, TERMINALS, STAMPINGS

and many similar fasteners are made in enormous variety and quantity. Made from most any metal and in all finishes. We also make a complete line of machines for attaching eyelets, rivets, etc.

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77 FRANKLIN AVENUE, BROOKLYN, N. Y.

IRE People

(Continued from page 74A)

John S. McCullough (A'47–M'51–SM'56) has joined Litton Industries Electron Tube Division, San Carlos, Calif., as assistant to the general manager. He will be responsible for new product planning, according to Dr. Norman H Moore, Litton vice president and division general manager.

J. S. McCullough

Previously director of research and engineering of Eitel-McCullough, Inc., Mr. McCullough attended the University of California and Harvard University.

❖

Daniel G. O'Connor (A'46–M'48–SM'52) has been appointed to the position of Assistant to Dr. R. L. Garman, Vice President in charge of engineering and research of the General Precision Equipment Corp. He will evaluate proposals and programs involving digital computers, and has been named a member of the Engineering Plans Committee.

He was transferred from the Link Di-

(Continued on page 78A)

10 TO 60 MILLIWATT SENSITIVITY!

terado SERIES 6000 MICRO RELAY

For Tube or Transistor Circuits:
Hermetic Seal
Plug in or Terminals

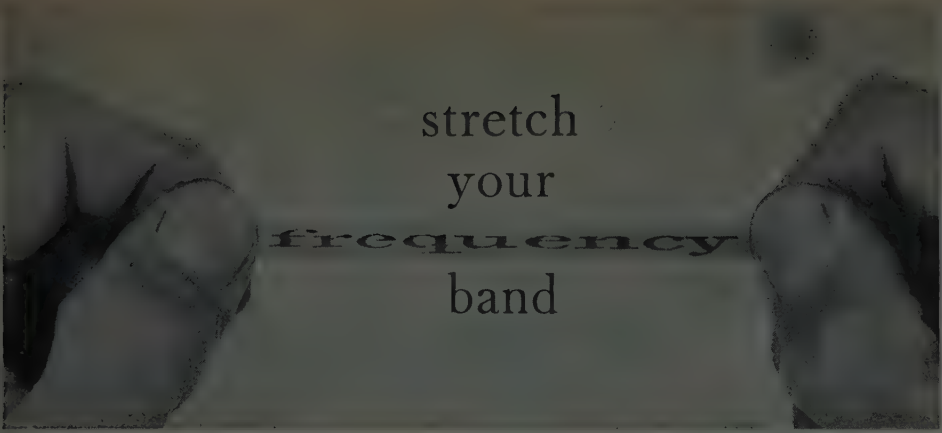
MICRO RELAY
TERADO
NO. A125A

(ACTUAL SIZE)

SPECIFICATIONS

- S.P.D.T. Switch
- 60 Milliwatt Nominal
  (Special to 10 Milliwatt)
- Rating—1 Amp., 24 V. Non-Inductive
- 24 to 10,000 Ohm Coils
- Vibration Characteristics Excellent
- Built to Match Your Circuit

TERADO COMPANY
1065 RAYMOND AVE. • ST. PAUL 8, MINN.



with new Hughes "20-20" Circulators!

With 20% bandwidth and over 20 db isolation, the new Hughes "Y" and "T" Circulators are ideally suited for microwave reception and transmission applications. They also give you small size and weight...without sacrifice in performance. C- and X-Band models are available today!

For information on the new "20-20" Circulators, or other advanced microwave components, please write Microwave Products Department, Advanced Program Development, Hughes Aircraft Company, Culver City 6, California. Or, phone UPton 0-7111, Ext. 6919.

	Model C-201A	Model X-230A (Illustrated)
Frequency:	4.9-6.2 Kmc	8.0-9.8 Kmc
Isolation:	20 db	20 db
Insertion Loss:	0.3 db	0.3 db
Input VSWR:	1.10	1.20
Power Capacity:	10 Kw peak 100W avg (Min.)	3 Kw peak 50W avg (Min.)

ALSO AVAILABLE: Miniaturized S- and L- Band Coaxial Circulators. New, extremely small (1″ x 2″ x 8″) circulators with bandwidths to 10%, over 20 db isolation, and 0.5 db insertion loss are now available.

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MICROWAVE PRODUCTS

ADDISON-WESLEY BOOKS
in electrical and
control systems

LINEAR CIRCUITS
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An introduction to linear circuits for students of electrical engineering. Assumes an introductory course in physics and concurrent calculus. Noteworthy features include: a balanced treatment of time and frequency domain methods; an integrated treatment of Fourier series and integrals, Laplace transforms, and power density spectra; and coverage of topics seldom found in books at this level, such as signal flow graphs, relaxation methods, dummy variables, s-plane plots, and complex resonance.

C. 400 pp., 1,000 illus., to be published Summer 1960—price to be announced

ANALYSIS OF LINEAR SYSTEMS
By David K. Cheng
Syracuse University

"A very fine book for the personal library of every engineer who has need for ready reference on linear systems theory and the use of Laplace and Z transforms."

Proceedings of the IRE
431 pp., 265 illus., 1959—$8.50

ORDINARY DIFFERENTIAL EQUATIONS
By Wilfred Kaplan
University of Michigan

"Deals thoroughly with all standard methods of integration . . . input-output analysis is given a prominent place . . . a thorough study is made . . . by means of phase-plane analysis . . . of great value to practicing engineers."

Applied Mechanics Reviews
534 pp., 150 illus., 1958—$9.75

ENGINEERING SYSTEMS ANALYSIS
By Robert L. Sutherland
State University of Iowa

"The second-order linear differential equation . . . is treated in detail for mechanical, electrical, and acoustical systems . . . offers excellent introductions to dimensional analysis, feedback and control, and analog and digital computers."

Physics Today
223 pp., 98 illus., 1958—$7.50

ADDISON-WESLEY PUBLISHING COMPANY, INC.
Reading, Massachusetts

IRE People

(Continued from page 76A)

vision of General Precision, Inc., a subsidiary of General Precision Equipment Corp., where he was responsible for a number of special projects including the Link Target Programmer, the Link Digital Function Generator, DOTitron and other special purpose digital computers. General Precision, Inc., provides all major military services, business and industry, with advanced electronic control and support systems.

Mr. O'Connor's experience includes four years of engineering planning and development activities in data processing at IBM, and five years research and development at the Physics Laboratory of Sylvania Electric Products, where he worked on guidance systems and electronic devices representing new advances in information theory. He has taught at IBM schools and in the Graduate School of Electrical Engineering at Polytechnic Institute of Brooklyn. He has done graduate work at Syracuse and Stanford Universities and the Polytechnic Institute of Brooklyn.

❖

Donald E. Nasoni (A'54) has been appointed staff engineer in Advanced Systems Simulation at the Owego facility of IBM's Federal Systems Division.

He entered Systems Studies at Owego in November, 1958 as an associate engineer. He was assigned to his present department last June.

A native of Scranton, Pa., he graduated from Central high school there and earned the B.S. degree in Electrical Engineering from Pennsylvania State University in 1952.

Mr. Nasoni is a member of the Association for Computing Machinery and the Scientific Research Society of America.

❖

C. A. Parry

Charles A. Parry (SM'53) international authority on telecommunication systems planning, has been named to head the newly-established Telecommunications Directorate at Page Communications Engineers, Inc., a Northrop Corporation subsidiary. Since coming to Page from RCA International in 1957, he has been consultant on the firm's overseas telecommunications projects. He will continue as Vice President-Engineering for the company's Italian affiliate, Edison-Page.

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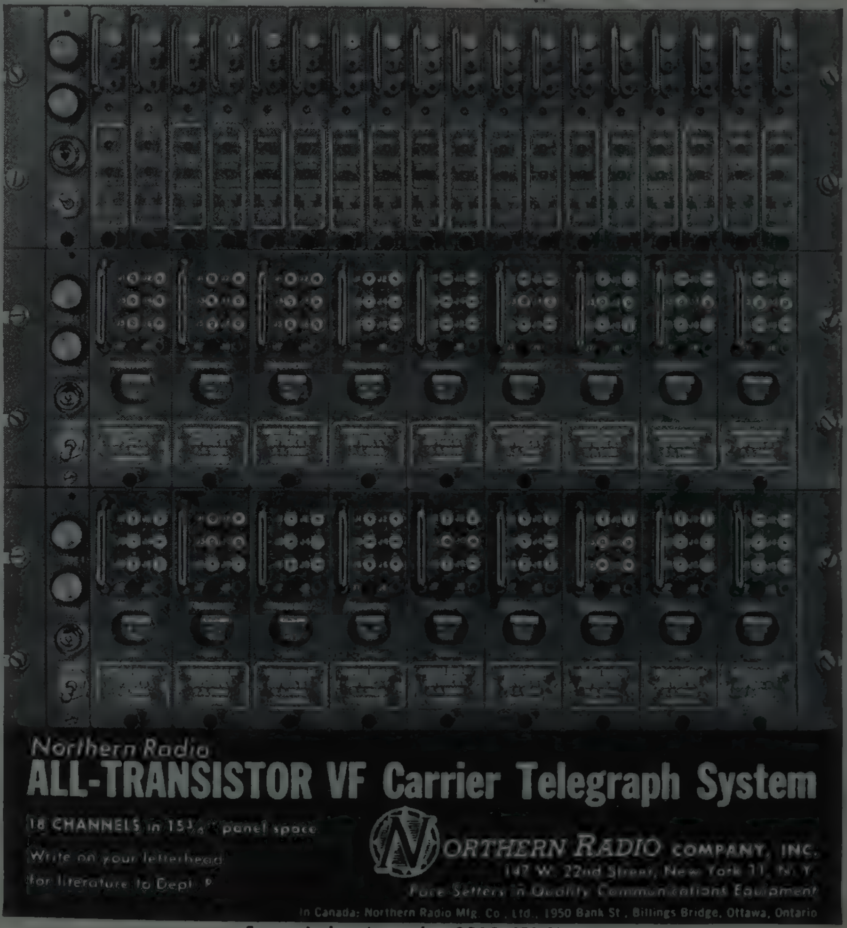
(Continued on page 80A)



Northern Radio
ALL-TRANSISTOR VF Carrier Telegraph System
18 CHANNELS in 15¾" panel space
Write on your letterhead for literature to Dept. P
NORTHERN RADIO COMPANY, INC.
147 W. 22nd Street, New York 11, N. Y.
Pace-Setters in Quality Communications Equipment
In Canada: Northern Radio Mfg. Co., Ltd., 1950 Bank St., Billings Bridge, Ottawa, Ontario
See us in booth number 3510, IRE Show.

NOW!

Bendix

25-AMP

POWER TRANSISTOR SERIES

Now in production by Bendix* are eight 25-ampere peak current power transistors capable of switching up to 1000 watts—and you can get immediate delivery on all eight types.

Newly improved in design, the transistors have a higher gain and flatter beta curve. The series is categorized in gain and voltage breakdown to provide optimum matching and to eliminate burn-out.

Current Gain hFE at Ic = 10 Adc	Maximum Voltage Rating			
	50 Vcb	60 Vcb	90 Vcb	100 Vcb
	30 Vce	40 Vce	70 Vce	80 Vce
20—60	2N1031	2N1031A	2N1031B	2N1031C
50—100	2N1032	2N1032A	2N1032B	2N1032C

Ask for complete details on this newly improved Bendix transistor series . . . and on the entire Bendix line of power transistors and power rectifiers. Write SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY, or the nearest sales office.

*TRADEMARK

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205 E. 42nd Street, New York 17, New York
Canadian Affiliate: Computing Devices of Canada, Ltd.,
P. O. Box 508, Ottawa 4, Ontario, Canada

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N.Y. IRE Show,
Booth 2226

SEMICONDUCTOR PRODUCTS

Red Bank Division

LONG BRANCH, N. J.

Bendix
AVIATION CORPORATION

Microwave energy normally travels on a two-way street. Because power flow has the habit of being reciprocal, it often becomes vitally necessary for microwave systems engineers to isolate the load from the transmitter or to control power channeling. Rantec **LOAD ISOLATORS** directionalize the power flow with a minimum loss in one direction of propagation and with extremely high loss in the other. Rantec manufactures a large number of "off-the-shelf" **LOAD ISOLATORS** which range from low power to liquid-cooled high power units and cover broad band as well as specific frequencies. Rantec engineers welcome the opportunity of solving specific problems or undertaking special design projects.

rantec *corporation*

calabasas, california

microwave ferrite components / antennas / r-f devices

SEE RANTEC AT PLAZA HOTEL DURING THE IRE SHOW

IRE People

(Continued from page 78A)

The appointment of **C. Robert Paulson** (S'48–A'50–M'52) to manager of the Professional Audio Products Division of Ampex Professional Products Company has been announced by Neal K. McNaughten, Ampex Corporation vice president and manager of the Ampex Professional Products Company, a totally integrated division of Ampex Corporation.

C. R. Paulson

Mr. Paulson replaces Frank G. Lennert who will remain with the company in an advisory capacity on audio matters.

As well as taking on his new duties as division manager, Mr. Paulson will continue in the position of marketing manager for the Professional Audio Products Division until a replacement is appointed.

He started with Ampex as New York district audio sales manager in 1953 and later moved to the main Redwood City offices as the first National sales manager for the Professional Products Division.

Prior to joining Ampex, he was sales engineer for Audio-Video Products, New York City; assistant producer for the Fred Waring Television Show; and staff engineer for the Thayer School of Engineering.

A graduate of Dartmouth College, he is a member of the Audio Engineering Society, the Armed Forces Communications System and the San Francisco Sales Executives Association.

During World War II, Mr. Paulson served as First Lieutenant with the Signal Corps, at Camp Crowder, Fort Monmouth and with the Allied Force headquarters in Italy.

❖

The Baltimore Division of The Martin Co. is being reorganized to take full advantage of its design, development and production capabilities for Space Age electronic, missile and other weapons systems.

J. J. Slattery

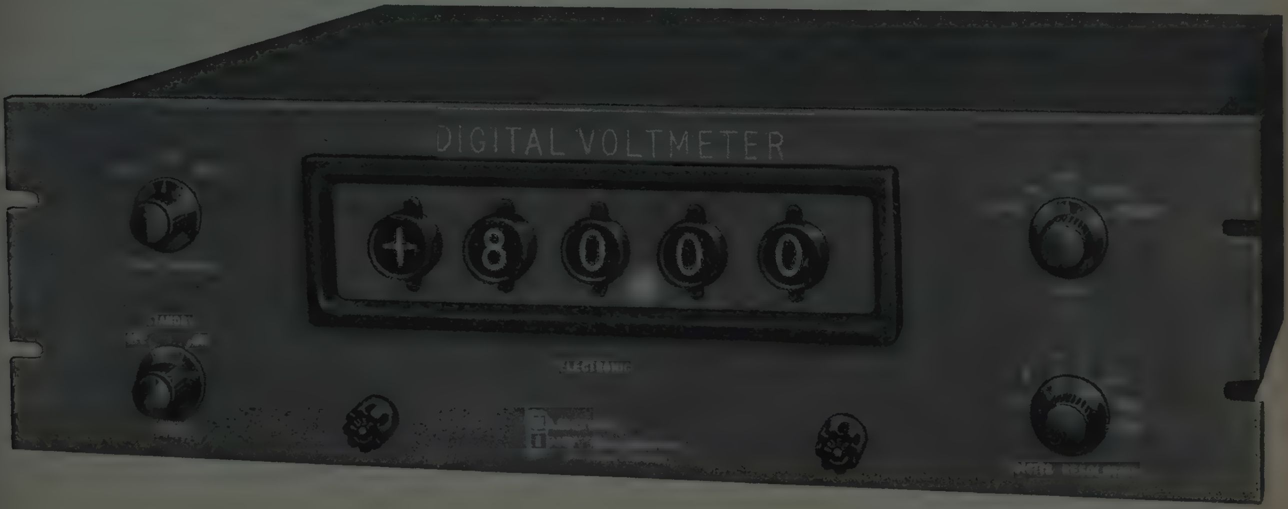
A. L. Varrieur, Vice President and General Manager, said the reorganization is to take effect immediately. It will include the establishment of a Martin-Baltimore Electronics Division with integrated engineering and production facilities.

Heading the Electronics Division as General Manager, reporting to Mr. Varrieur, is **John J. Slattery** (J'29–A'30–SM'46–F'56), former manager of West Coast Operations for the Magnavox Company's Government and Industry Division

(Continued on page 82A)

New, Electro Instruments all-electronic, totally transistorized digital voltmeter

50 conversions per second • 1000 megohms input impedance • Fully automatic ranging



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Plus accessory modules for every application

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Ohmmeter: All transistorized Model KIM-000. Provides constant current through test resistor with negligible power dissipation. Voltage measurements made across resistor and read out directly in ohms with fully automatic ranging.

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A large 4½" meter is used for indication, with clear, sharp calibrations for all ranges. Precision 1% resistors are used for high accuracy and the printed circuit board gives high circuit stability and speeds assembly. The 11-megohm input resistance of the V-7A reduces "loading" of the circuit under test resulting in greater accuracy. Whether you order the factory wired ready-to-use model or the easy-to-assemble kit, you will find the V-7A one of the finest investments you can make in electronic workshop or lab equipment.

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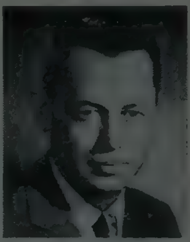
(Continued from page 80A)

at Los Angeles. His experience also includes design and development assignments with Bell Telephone Laboratories and RCA Manufacturing Company, and both civilian and military duty with the U. S. Army Signal Corps.

At the Signal Corps Engineering Laboratories he helped develop radar and counter-measure systems, and was responsible for systems design and engineering of the first U. S. searchlight control radar. He holds the B.S. degree in electrical engineering from Villanova University and the M.S. degree in physics and mathematics from Stevens Institute of Technology.

❖

B. Linn Soule (M'59) has been appointed liaison engineer for Packard Bell Electronics in the Dayton, Ohio office.



B. L. Soule

He was employed for the past eight years by the Hazeltine Corporation as a field engineer specializing in systems of ground radar, airborne early warning radar, mission and traffic control, radar judicating and Doppler battlefield surveillance. In addition to assignments in the United States, he has also served in Japan, Korea, Puerto Rico, Alaska and the European continent.

Mr. Soule was graduated from the University of Michigan with the B.S. degree in electrical engineering. He holds an amateur radio operator's license and is a member of the Ohio Society of Professional Engineers and the National Society of Professional Engineers.

❖

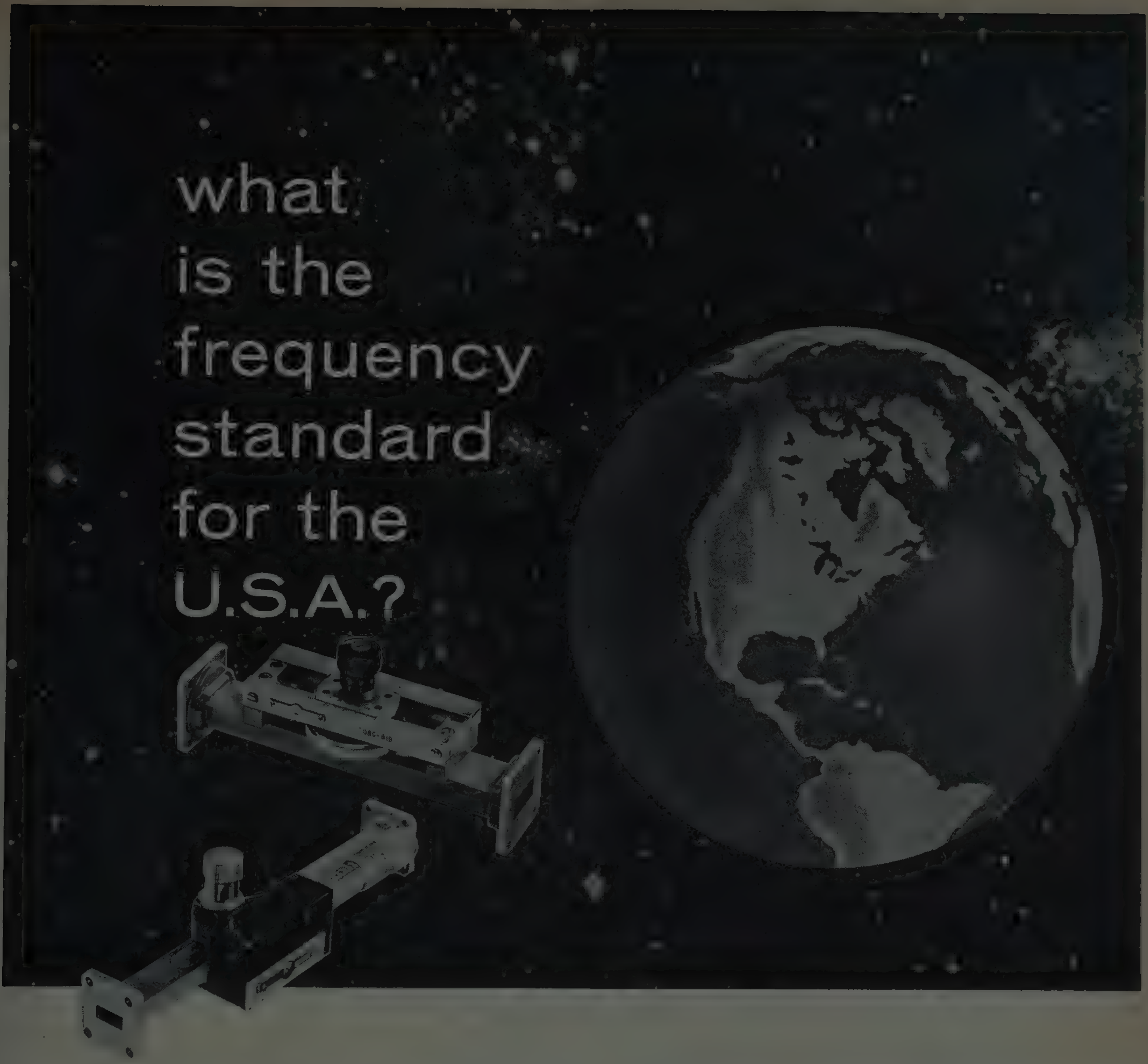
The appointment of **Robert S. Stein** (A'47–SM'53) as Director of Technical Publication Services has been announced by Boland & Boyce, Inc., technical publications specialists with offices in New York, N. Y., and Madison, N. J. Mr. Stein will assume full responsibility for technical manuals, brochures and other publications prepared by Boland & Boyce.

R. S. Stein

He joins Boland & Boyce with a thorough background in the field of technical publications. For the last nine years he was editor-in-chief of Coastal Publications Corp. Prior to that, he held positions as project director, editor, writer and instructor for several other firms in the same field.

After receiving his degree in electronic

(Continued on page 84A)



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IRE People

(Continued from page 82A)

engineering from Georgia Institute of Technology in 1944, Mr. Stein served as a radio officer in the Army Signal Corps. Upon completing his military service he did graduate work in television engineering at Columbia University.

❖

The Sperry Microwave Electronics Company recently announced the promotion of **Leonard Swern** (A'49–M'53–SM'57) to Engineering Department Head. In this capacity he is responsible for all microwave solid state activities, as well as research and development of microwave system components and antennas.

L. Swern

A former Section Head for Applied Physics, he joined Sperry Microwave ten years ago after receiving the M.A. degree in physics from Columbia University.

He is a member of the American Physical Society, and is serving on the Editorial Board of the IRE Transactions on Microwave Theory and Techniques.

Past works have included design of microwave bolometers, research involving interactions between microwaves and matter, and microwave research and advanced developmental work on the properties of ferrites and other anistropic media at microwave frequencies.

❖

Advancement of two staff members in Stromberg-Carlson's Research Division to new responsibilities has been announced by Dr. Nisson A. Finkelstein, assistant vice president and director of research. Stromberg-Carlson is a division of General Dynamics Corporation. The men, and their new positions, are: **Robert B. Taylor** (M'57–SM'59), manager of engineering services, and **Dr. Ernest G. Brock** (SM'56), a principal scientist in the Basic Science Laboratory.

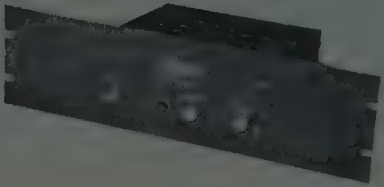
R. B. Taylor

E. G. Brock

Mr. Taylor has been with Stromberg-Carlson since 1955, when he joined the company as a research engineer specializ-

(Continued on page 88A)

CECO



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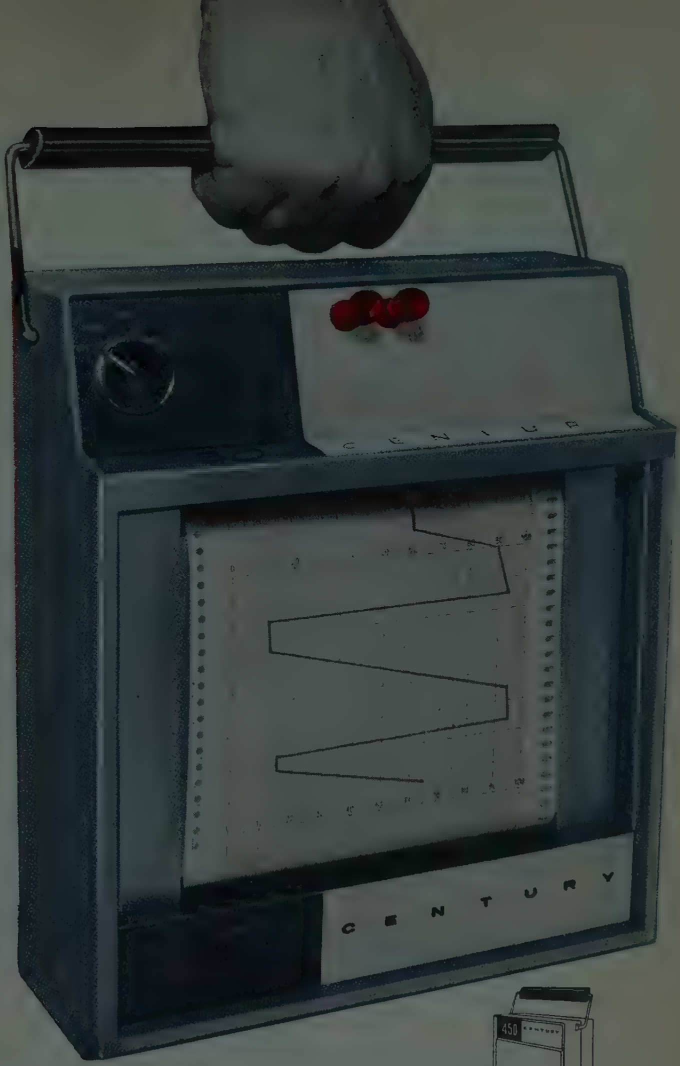

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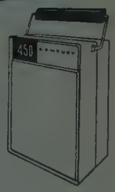

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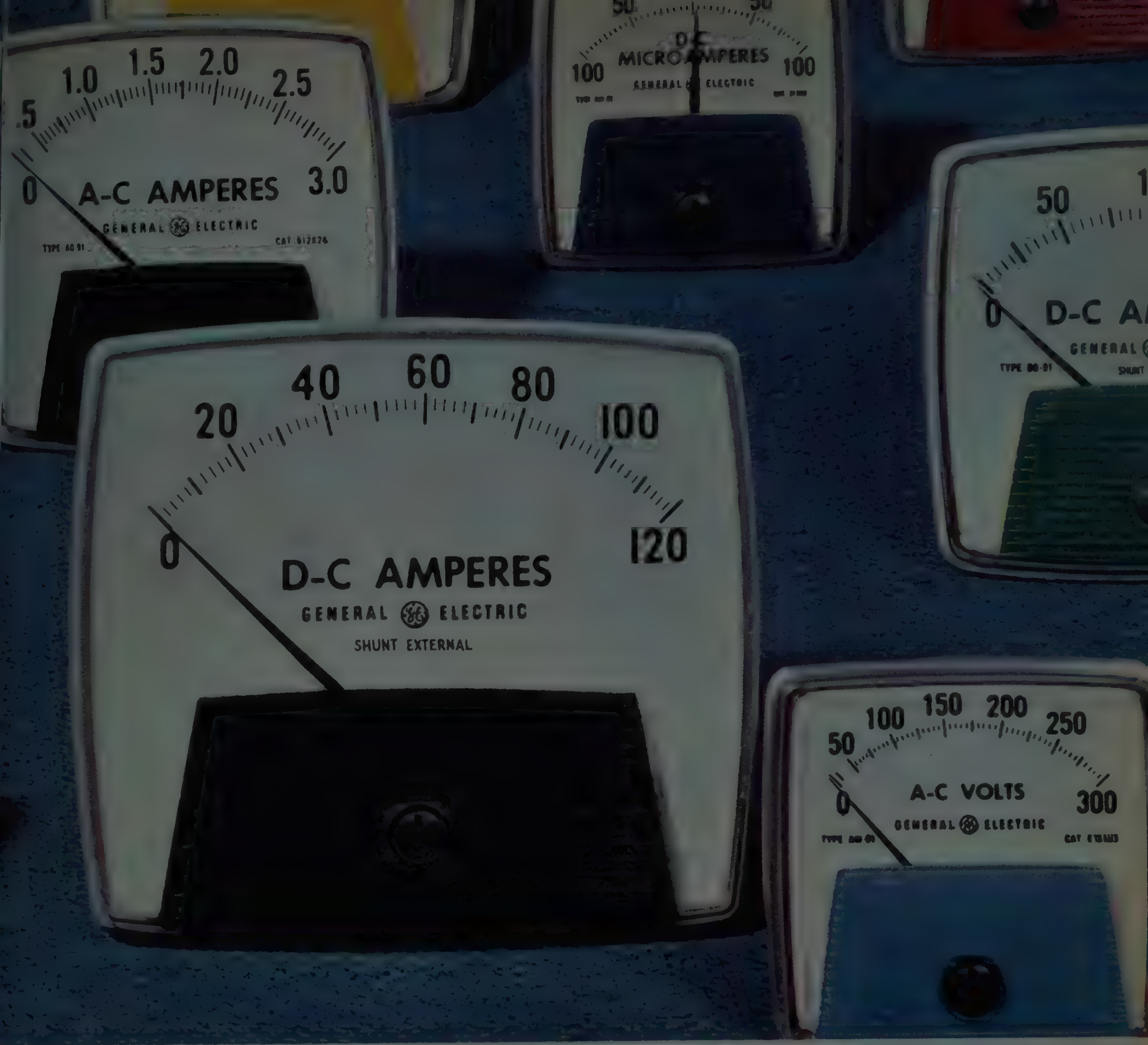
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(Continued from page 84A)

ing in solid-state circuit design. Subsequently he became staff engineer to the director of research, with principal responsibility for the negotiation and administration of reimbursable research contracts. He received the B.S. degree in electrical engineering from the University of Rochester, and prior to joining Stromberg-Carlson worked as a research engineer at the Delco Appliance Division of General Motors Corporation. He is an officer in the U. S. Naval Research Reserve Company 3-4.

Dr. Brock joined Stromberg-Carlson's Research Division in 1958 as a senior physicist, and has been specializing in studies of molecular resonance. He received the B.S. and Ph.D. degrees from the University of Notre Dame, and before coming with Stromberg-Carlson served as a research associate in the General Electric Research Laboratory, Schenectady, N. Y., and as a group leader at the Linfield Research Institute, McMinnville, Oregon. He is a member of the American Physical Society.

❖

Announcement of the appointment of **Raymond W. Wells** (SM'55) as Director of Engineering has been made by Joel M. Jacobson, President of Aircraft Armaments, Inc., Cockeysville, Md. Mr. Wells will be responsible for the direction of all development and production engineering activities at Aircraft Armaments, Inc., including the management of the company's six engineering departments: Electronics, Electro-Mechanical, Structures, Ordnance, Aerodynamics and Nuclear Physics, and Engineering Services. He has been with Aircraft Armaments, Inc., since 1953, when he joined the organization as Project Engineer. He served as Chief Electronics Engineer from 1955 to his present assignment and in this capacity supervised research and development of numerous, advanced electronic programs, including countermeasures, missile and radar test equipment and instrumentation, and microwave and antenna systems.

R. W. WELLS

Mr. Wells is a graduate of Iowa State College, where he received the B.S. degree in Electrical Engineering in 1942. Between 1942 and 1946 he was Associate Engineer at Wright Field Aircraft Radio Laboratory and was responsible for circuit development work on airborne IFF equipment. In 1946 he worked at Bendix Radio on the development of AM and FM communication receivers, and from 1946 through 1952 he was associated with the Glenn L. Martin Company as Project Engineer on air-to-air missiles. He is an active member of the American Ordnance Association and the Association of the U.S. Army.

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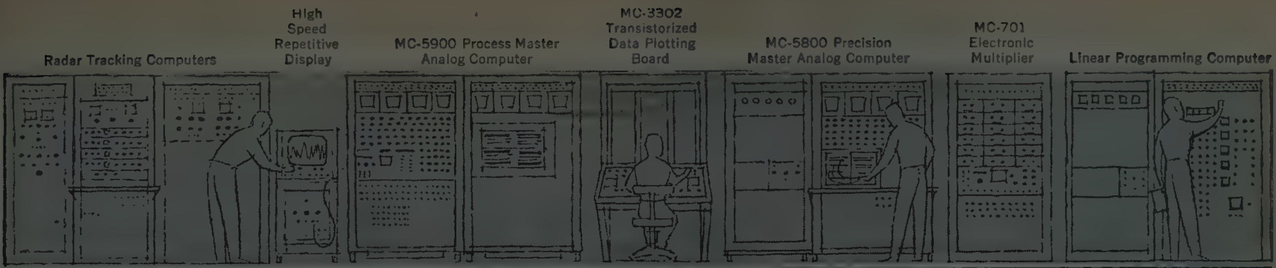
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IRE People

(Continued from page 88A)

Professor **Arthur W. Melloh** (A'33–SM'45) of the University of New Mexico faculty has been named professor of electrical engineering and dean of The State University of Iowa College of Engineering by the State Board of Regents.

The appointment will be effective July 1. As head of the SUI engineering college he succeeds Dean Francis M. Dawson, who retired in 1957 after 21 years as dean. At the request of University officials Dean Dawson had continued serving while a successor was sought, but illness forced him to widhdraw from active duty in the college early last year.

The new Iowa engineering dean, 52, is a native of Minnesota, and earned the B.E.E., M.S. and Ph.D. degrees from the University of Minnesota, where he also served as instructor for four years.

His subsequent employment included two years as research engineer for Automatic Electric Co. of Chicago, three years with the San Diego Radio and Sound Laboratory, and two years as senior research engineer for Stromberg-Carlson Co. in Rochester, N. Y. From 1947 to 1956 he was vice-director of the Texas Engineering Experiment Station, a branch of Texas A & M College, and since 1956 he has been professor of electrical engineering at the University of New Mexico, Albuquerque.

(Continued on page 92A)

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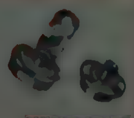
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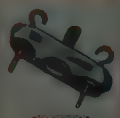
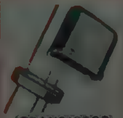

CUSTOM SEALING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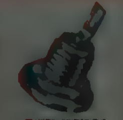
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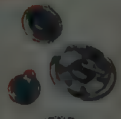
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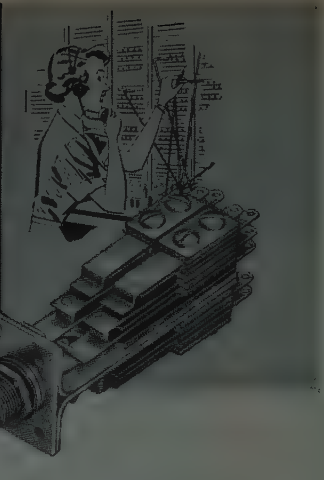

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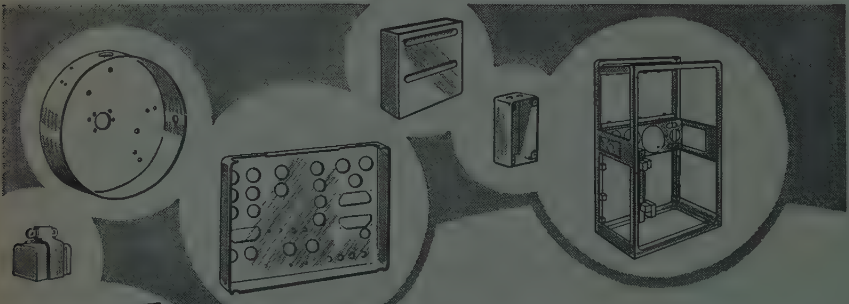

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Stock dies on hand for many shapes.

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IRE People

(Continued from page 90A)

Dean Melloh is the author of four instructional books for the U. S. Navy, three Experiment Station Bulletins, and five publications in technical journals. His professional memberships include the American Institute of Electrical Engineers, American Society for Engineering Education, Sigma Xi, Tau Beta Pi, and Phi Kappa Phi. He is a Registered Professional Engineer in the State of Texas.

Industrial Engineering Notes*

ASSOCIATION ACTIVITIES

The auditorium at Electronics Park Syracuse, N. Y., has been designated W. R. G. Baker Hall in honor of Dr. W. R. G. Baker, retired Vice President of General Electric, former Director of the EIA Engineering Department, and past President of the Association. One of the leading pioneers in the field of electronics, Dr. Baker now is Vice President for Research at Syracuse University and President of the Syracuse University Research Corp. He is also treasurer of the IRE. The announcement of the new designation of the auditorium was made at a luncheon held at Electronics Park in honor of Dr. Baker's 67th birthday. . . . **A special EIA subcommittee studying color picture concepts advanced by Dr. Edwin H. Land, head of the Polaroid Corp., has urged that "Dr. Land and others be encouraged" to continue their basic studies, but recommended that the FCC color TV signal be left unchanged "at this time."** The subcommittee, formed early last year by the EIA committee on Broadcast Television Systems, stated that the FCC signal "permits continued investigation of Dr. Land's method without deterioration of pictures reproduced by receivers making full use of the information present in the signal." The FCC color signal, the subcommittee pointed out in a statement of its findings, "carries simultaneously the information for three-color reproduction and for methods outlined by Dr. Land" and "does not result in a large increase in the cost of receivers." The subcommittee's statement on the work of Dr. Land was signed by the BTS; Committee Chairman, Charles J. Hirsch. . . . EIA has gone on record with the FCC as supporting the proposed reallocation of the 460–461 mc from the Citizens Radio Service to the Industrial Radio Services.

In a filing of FCC Docket No. 11959 (FCC Second Notice of Proposed Rule Making), the Association stated: "We be-

(Continued on page 94A)

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* The data on which these NOTES are based were selected by permission from *Weekly Report*, issues of December 21, 1959 and January 4, 11 and 18, 1960, published by the Electronic Industries Association, whose helpfulness is gratefully acknowledged.

Waters new pots conquer space

Two new 1/2″ Waters pots conquer a space problem for many a harassed space age engineer. Both require up to 25% less space behind the panel than pots having identical specifications. Available with terminals (shown), wire leads or printed circuit pins. Case lengths are only 3/8″. The new APS 1/2 is designed for bushing-type mounting. The WPS 1/2, designed for servo mounting, is the smallest potentiometer available for general use in rugged servo applications. Both are capable of dissipating 2 watts continuously! Reliability test reports available. Write for Bulletin APS-160.

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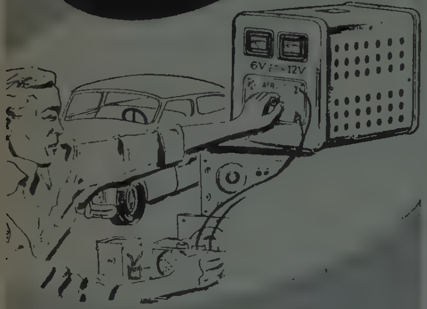

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For Demonstrating and Testing Auto Radios

TRANSISTOR OR VIBRATOR OPERATED
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610C-ELIF	110	6	10	20	22	$49.95
		-or-				
		12	6	12		
620C-ELIT	110	6	20	40	33	[redacted]
		-or-				
		12	10	20		

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Industrial Engineering Notes

(Continued from page 92A)

lieve that the proposed reallocation of frequencies . . . represents forward-thinking in spectrum utilization and therefore urge its adoption."

Also recommended was transfer of 465.475-466.475 mc to the Industrial Radio Services as a companion megacycle with the Commission's proposed transfer of the 460–461 mc band.

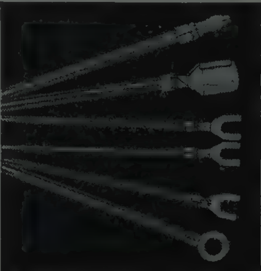
Electronics Abroad

The Japanese government has decided to adopt the NTSC color TV system and formal announcement will be followed quickly by issuance of a station license to the NTV network. This will make Japan the second nation in the world, following the U. S., to have commercial color TV. Because the price of a color TV receiver will be almost a year's gross wages for the average factory or office worker in Japan even after mass production of fairly small sets is achieved, the chances are remote of color TV reaching even a fraction of the homes in Japan, the report from there stated. At present, it is estimated, one million black-and-white TV receivers have found their way into one Japanese home in 20. . . . **Imports of electronic products into the U. S. during the first nine months of 1959 totaled in excess of $48.8 million and were more than two and one-half times those of the same period last year while other exports declined slightly, the Electronics Division, BDSA, reported.** Among the increased imports were: Radio apparatus and parts. The rapid rise in these imports-from $3.4 million in 1955 to $28.2 million in 1958 took $43.3 million during the first nine months of 1959—attributable principally to the increased shipments of radio receivers from Japan. Significant among current Japanese shipments of electronic products to the U. S. are radio receivers-principally transistor portable. Japanese shipments of radio receivers of all types (not included radio phonographs) to the U. S. numbered 641,208 in 1957; 2,506,920 in 1958 and 3,900,222 in first nine months in 1959; valued at $5.3 million; $17.9 million and $37.5 million, respectively. Exports of record players and record changers to the U. S. from the United Kingdom alone were valued at $7 million in 1957, $9.2 million in 1958, and $4.5 million in the first half of 1959. The U. S. is by far the most important single foreign market for UK electronic producers, accounting for $17.2 million in 1958 compared with exports of $8 million to Australia and $7.8 million to Canada, the next largest market. UK imports of electronic products from the U. S. in 1958 were valued at $8.1 million.

Engineering

The National Bureau of Standards has announced that the handbook PREFERRED CIRCUITS, Navy Aeronautical Elec-

(Continued on page 96A)



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2-1/2 to 1 reduction. For fine tuning applications. Ball
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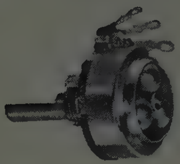

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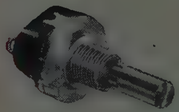

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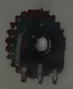

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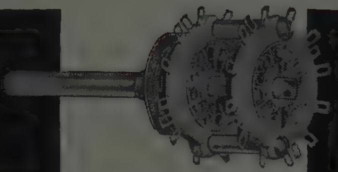

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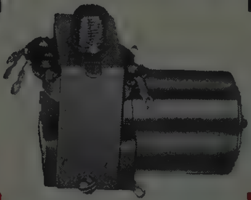

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(Continued from page 94A)

tronic Equipment, NAVAER 16-1-519, Supplement No. 2, 54 pages, dated April 1, 1959, is available from the Government Printing Office, Washington 25, D. C., price 30 cents, in looseleaf format. The supplement contains 5 circuits and a note on preferred regulated voltages for transistorized equipment. The aim of the preferred circuits program is the voluntary reduction of unnecessary circuit variations in military equipment. . . . **Progress by one Navy engineering contractor in improving the thermistor infrared detector during five years of research and development is reviewed in a report just released to industry through the Office of Technical Services, U. S. Department of Commerce.** Also available is a Navy report on problems and advances, to mid-1954, in development of photoconductive detectors for infrared atomic spectroscopy. The two volumes are: *Thermistor Infrared Detectors: Part 1—Properties and Developments.* (Order PB151767 from OTS, U. S. Department of Commerce, Washington 25, D. C., $2.75.) *Infrared Atomic Spectroscopy, Based on Use of Photoconductive Detectors.* (Order PB 151953 from OTS, U. S. Department of Commerce, Washington 25, D. C., $1.25.)

MILITARY ELECTRONICS

The Pentagon's list of the top 100 defense contractors in fiscal year 1959 is changing in composition compared with former years, a close examination reveals. A heavy preponderance of the first 25 contractors are engaged in missile or electronic production. General Dynamics won top place with total awards of $1.6 billion or 7.2 per cent of the total of defense dollars. This compares with 6.4 per cent awarded to this firm in FY 1959. It is understood that over 80 per cent of the company's defense contracts involved missile-electronic-aircraft programs. Boeing Airplane Co. dropped to second place with net contracts totaling $1.167 billion; North American moved back up into third place with contracts totaling $1.018 billion and it is understood that cancellation of the F-108 and the stretchout of the B-70 bomber will affect its position in later reports. General Electric remained in fourth place with $914 million in new awards and its share of DOD dollars increased from 3.6 per cent in FY 1958 to 4.1 per cent in FY 1959. Lockheed Aircraft was placed fifth with $898.5 million or 4 per cent of total defense dollars, and Douglas Aircraft was in 6th place with $676.4 million in new contracts. United Aircraft, which dropped out of the top 10 in FY 1958, moved from 14th to 7th place with new awards totaling $538.2 million or 2.4 per cent of defense dollars. The Martin Co., in the top 10 for some time, was placed 8th with $524 million; Hughes Aircraft was ninth with $494 million, and AT & T was 10th with $476.5

(Continued on page 98A)

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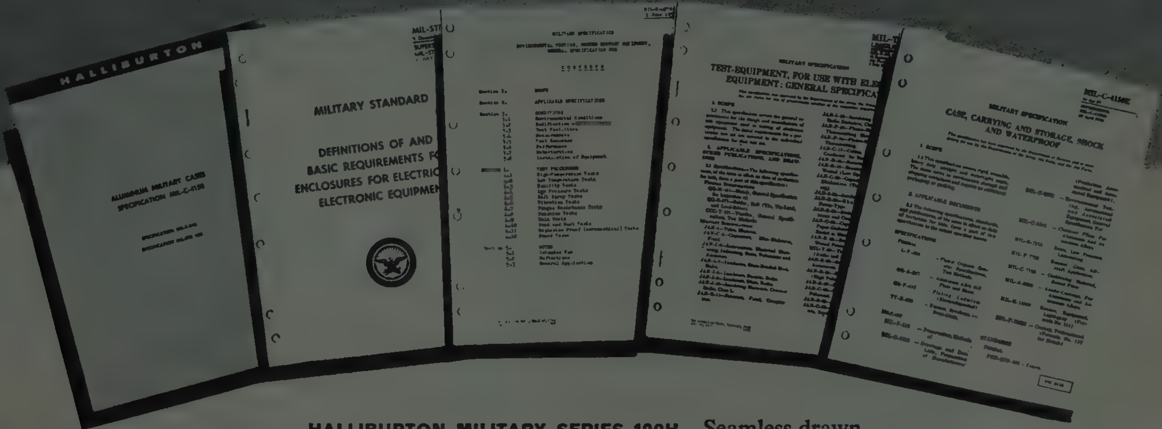

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HALLIBURTON MILITARY SERIES 120H—Seamless drawn, heat treated aluminum, Series 120H Cases . . . available in all sizes . . . provide watertight, airtight and shockproof, heavy duty reusable cases for the carrying, transit and storage of aerial cameras, electronic controls and devices, aerological equipment, navigation instruments and other military equipment. The performance characteristics of these cases comply with the environmental conditions of humidity, extremes of temperature, fungus, salt laden atmosphere, shock, tumbling and submersion, in accordance with the provisions of Military Specification MIL-C-4150E. Series 120H Cases also conform to the construction and performance requirements of Specifications MIL-T-945A, MIL-STD-108C, Class I, Type Watertight, as electronic instrument and/or combination cases, MIL-T-4734, MIL-T-4807, MIL-E-4970, and other applicable standards.

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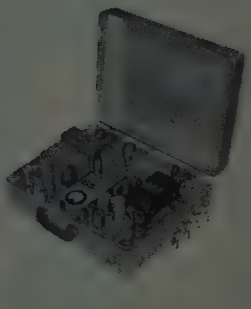
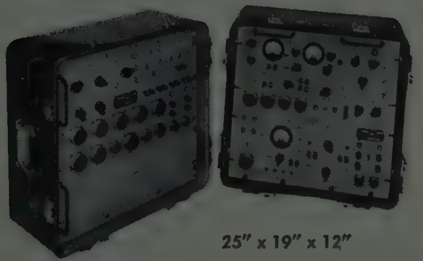


13″ x 21″ x 6½″



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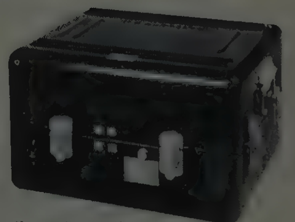
13″ x 18″ x 6″



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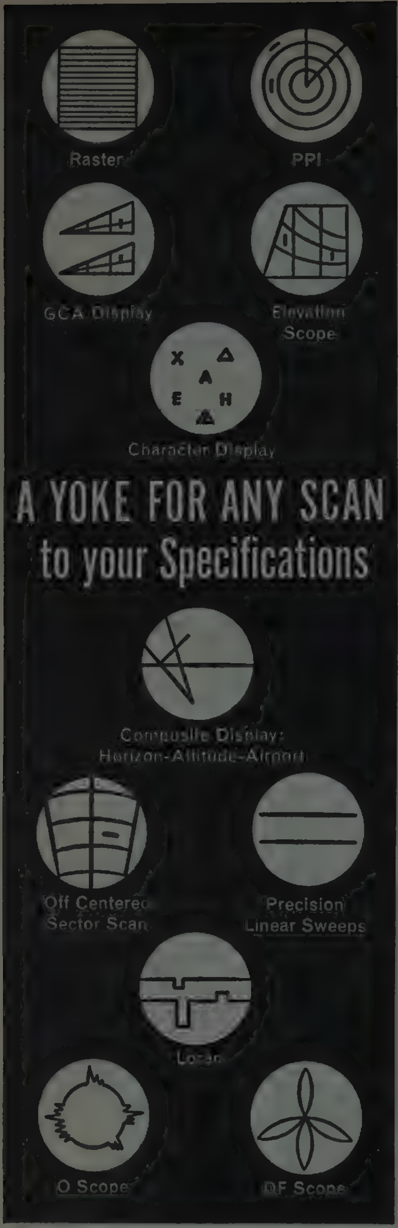

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Industrial Engineering Notes

(Continued from page 96A)

million. The next 10 contractors comprised a mixture of missile-electronic-aircraft manufacturers and were listed as follows: McDonnell Aircraft, $403.5 million (not including the MERCURY program); Sperry Rand, $403.2 million; Raytheon Co., $392.6 million; Chrysler Corp., $323.2 million; Grumman Aircraft, $300.2 million; Republic Aviation, $280.5 million; IBM $276.9 million; Bendix Aviation, $271.3 million; Westinghouse Electric, $238 million; and General Motors Corp., $210.7 million. The DOD reported that in FY 1959, aircraft and missile contracts accounted for 64 per cent of the value of awards of $500,000 or more to these companies, and electronics contracts accounted for an additional 11 per cent. Also, the DOD said, 59 of the 100 companies are engaged directly in aircraft and missile work, or in electronics and R&D work directly related to aircraft and missile programs. . . . **The DOD has made public what it calls the first comprehensive guide to available military technical resources in a single broad area of technology—in this case, the field of missile ground support equipment.** The directory is designed to encourage a maximum exchange of technical information in the military departments and in industry, with the prime pur-

(Continued on page 100A)

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Wind surface—13.36 sq. ft. Load at 100 mph.—423 lbs.
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Antenna rated design with ½" radial ice—110 mph.

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- Measures 150 kilocycles to 1000 megacycles accurately and quickly with only one instrument.
- For measurements in accordance with Specifications: MIL-I-6181B, Class 1; MIL-S-10379A; MIL-I-11683B; MIL-I-11748B; MIL-I-12348A; MIL-I-13237; MIL-I-16910A; MIL-I-26600 (USAF), Category A; F.C.C. Specifications.
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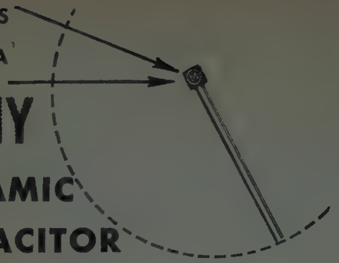
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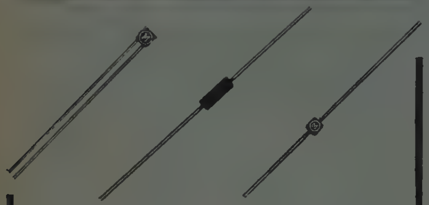

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Industrial Engineering Notes

(Continued from page 98A)

pose of avoiding the duplication of effort, the DOD said. The 15-page publication lists almost 200 items of equipment associated with missile GSE, with the name, location, and telephone number of the military personnel conversant with the latest developments in each field. Rhw publication is the most immediate and end-product of a study on missile GSE which has been in progress since March, 1958. The publication, "Technical Resources Directory," may be obtained from the Office of Technical Services, Department of Commerce, at 50 cents a copy, and should be ordered by number—PB 161103.

OUTLOOK FOR 1960

A record-breaking year is in prospect for the electronic industries in 1960, according to the Business and Defense Services Administration, Commerce Department, and the outlook "is excellent for all product lines." The combined output of these industries, the report states, "is expected to reach the $10 billion level for the first time in their comparatively short history." A summary of the BDSA projections in the consumer, military, industrial, tubes-semiconductor, and parts industries follows:

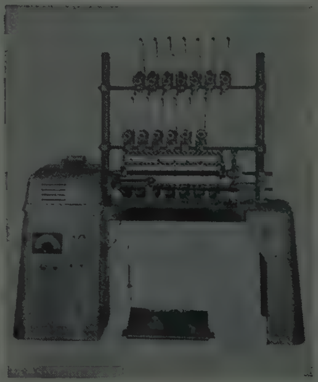
Consumer Products—Factory sales of consumer type electronic products, already at a record high of $1.95 billion, are expected to reach a level of $2.2 billion in 1960. *Military Electronic Equipment*—The production of electronic equipment for military services and for the Space Agency should continue upward in 1960, at the rate of better than 15 per cent. *Industrial Electronic Equipment*—A good year lies ahead for manufacturers of commercial and industrial electronic equipment. Indications are that the demand for these products will continue upward, with gains in 1960 of at least 10 per cent over-all. *Electron Tubes*—Total factory sales of electron tubes are expected to be up 5 to 6 per cent in 1960 from 1959 levels. *Semiconductor Devices*—The factory sales of semiconductor devices—transistors, diodes, and rectifiers—rose by 75 per cent, from $210 million in 1958 to $370 million in 1959. Equally vigorous growth is expected in 1960, although at a lower rate—about 30 per cent. Shipments should approach a total of $470 million by the end of the year. *Other Electronic Components*—All types of electronic components should share in the rise in output forecast for 1960. Factory sales increased nearly 20 per cent in 1959, and should increase further in 1960, by about 12 per cent, bringing the total for the year near $1.8 billion.

REVIEW OF 1959

Year-End Statement by David R. Hull, President, Electronic Industries Association: At the close of business on December 31, the electronics industry will have

(Continued on page 102A)

NEW GEARLESS MULTIPLE
TRANSFORMER WINDER
with Instant Spiral/Rapid Traverse



7 TIME-SAVING FEATURES: 1) Unique wire carriage quickly shifts into coils' margin, adds extra turns for lead purposes. 2) Shorter set-up time. 3) No gear changing–pitch selector permits instant selection of turns per inch range. 4) Instantly adjustable winding width. 5) Winding cycle instantly reset by touching counter lever. 6) Instant spiral/rapid traverse device. 7) Front loading of tension permitted by compact machine design.

Model 405-AM multiple winds paper section power, audio, fluorescent ballast and similar transformer coil types up to 9″ OD if round, 4½″ OD if rectangular, 6″ long, using wire sizes 16-44. Maximum center to center distance for adjustable wire guide rollers 23½″, distance between head and tailstock 33″ max. & 21″ min., winding range 19-454 turns per inch, winding speed up to 2000 RPM, output end of spindle ⅞″ flatted shaft. Furnished with motor, counter, brake, tailstock, tilting table paper feed & 20 tensions with new support bracket permitting vertical, horizontal & angular tension adjustment.

Reduce winding costs and time with Model 405-AM.

GEO. STEVENS MANUFACTURING CO., INC.
Pulaski Road at Peterson, Chicago 46, Illinois
The Most Complete Line of Coil Winding Equipment Made

when you can't afford power failure

Borg sub-fractional horsepower motors mean reliable power for your precision instruments and equipment. All Borg motors are totally enclosed, using precision machined die-cast alloys for end bells and gear-train housings. Borg motors are reversible, capacitor-type motors rated for operation on 110 and 220 volts, 50 or 60 cycles. Available in synchronous or induction types, two or four pole, with or without gear trains, from 1/750 to 1/2000 horsepower. Capacitors are optional. Contact your nearest Borg distributor or technical representative, or write us for full information.

WRITE FOR
DATA SHEET
BED-A132

BORG EQUIPMENT DIVISION

Amphenol-Borg Electronics Corporation
Janesville, Wisconsin

Micropot Potentiometers • Turns-Counting Microdials • Sub-Fractional Horsepower Motors • Frequency and Time Standards

TUBE PROBLEM:

The Armed Forces needed a new version of the 6J4 reliable tube type which would provide a tube life of almost 1000 hours. Existing tubes of this type had an average life of only 250 hours. In addition, this new tube had to be produced under ultra-high quality control standards.

SONOTONE SOLVES IT:

By making improvements in the cathode alloy and setting up extremely tight controls in precision, manufacture and checking, Sonotone engineers produced a 6J4WA with a *minimum* life of 1000 hours...most running *much longer*.

RESULTS:

The Sonotone 6J4WA is one of three reliable tubes now being manufactured under U.S. Army Signal Corps RIQAP (Reduced Inspection Quality Assurance Program), monitored by the U.S. Army Signal Supply Agency. And the same rigid quality standards apply to Sonotone's entertainment type tubes as well.

Let Sonotone help solve *your* tube problems, too.

Sonotone. CORP.
Electronic Applications Division, Dept. T42-30
ELMSFORD, NEW YORK
Leading makers of fine ceramic cartridges, speakers, microphones, tape heads, electron tubes.
In Canada, contact Atlas Radio Corp., Ltd., Toronto

Industrial Engineering Notes

(Continued from page 100A)

achieved an unbroken succession of new all-time highs in total factory sales for every year of the decade of the 1950s. We believe the 10-year record, which twice in the period ran directly counter to national economic recessions, has few parallels in the recent history of American industry. On the basis of information now available, the industry's total 1959 business, at the factory level, may be estimated at $9.2 billion. This is more than 3½ times the total for the first year of the decade and represents an increase of nearly 16 per cent over the previous high of $7.94 billion established in 1958. Every major segment of the industry reached new peaks in sales during 1959. In only two other years of the last ten—1956 and 1957—were records established on a comparable across-the-board basis. Manufacturers of consumer products made a substantial comeback from the 1958 recession with a 1959 sales total of $2.05 billion, or $450 million better than last year. The 1959 figure of $1.1 billion for replacement parts, tubes, and semiconductors is $240 million higher than 1958. Industrial and military products set new highs for the tenth year in a row with totals of $1.55 and $4.5 billion. These were $170 and $400 million, respectively, over 1958. The industry's record as a creator of jobs

(Continued on page 104A)

the transformer you need is probably among the

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rpc
IMPROVED RESISTANCE NETWORKS

Recent advances in equipment and techniques with measurements of 1 PPM resolution enable us to supply resistance networks of unusual accuracies and characteristics as required for computers, summing networks, voltage dividers, etc.

We are currently producing in quantity for major defense contractors to various specifications of phase angle, D.C. and A.C. ratios with controlled frequency characteristics.

Hermetic sealing or full encapsulation enable networks to meet applicable portions of MIL-R-93B and MIL-STD-202A.

Our Engineering Department will gladly advise the limits of accuracies and physical sizes that may be attained for your specifications.

RESISTANCE PRODUCTS COMPANY
914 South 13th Street, Harrisburg, Pa.

This man is using the industry's most advanced swept microwave oscillator

now available from ALFRED ELECTRONICS

No other sweeping oscillators offer as many solid advantages as Alfred Electronics' new series 620 models, built by the industry's leading manufacturer of high quality, broadband microwave instruments. Note these features:

★ **Six models, covering 1 to 18 kmc.** Broadest frequency range available. Electronic sweep of RF output, or extremely stable CW operation.

★ **Linear frequency sweep coverage** over all or part of each band for rapid evaluation of reflection coefficient, gain, attenuation and other network transfer characteristics.

★ **Two adjustable frequency markers** for convenient calibration of oscilloscopes or recorders. Markers save valuable test time by indicating either band limits or intermediate frequency values. An exclusive Alfred feature on all models.

★ **0.5 microseconds rise and fall** response to AM—equivalent to a 2 megacycle band pass. Another exclusive Alfred feature.

★ **Quick Look readout.** See frequency range, markers and sweep time at a glance. No cumbersome calculating.

★ **Fast sweep** for flicker-free oscilloscope presentation; slow sweep for mechanical recorder operation.

Using Alfred Model 623 Microwave Oscillator (left) to test small signal and saturation gain of Model 503 Traveling Wave Tube Amplifier. Microwave Leveler, Alfred Model 704, holds power output from oscillator constant within ±1 db.

BRIEF SPECIFICATIONS

Model	621	622	623	626	624	625
Frequency Range (kmc)	1-2	2-4	4-8	6.5-11.5	8-12.4	12.4-18
RF Output Connector	"N" Female	"N" Female	"N" Female	"N" Female	"N" Female	"P" Band Cover Flange UG/419/U
Prices	$3090	$2990	$2890	$2990	$2890	$3450

GENERAL

FREQUENCY CONTROL: Continuously adjustable with direct calibrated dial. Calibration accuracy, 1%.

POWER OUTPUT (minimum): 10 mw. Continuously adjustable from zero to maximum.

VSWR (maximum): 2:1.

SWEEP

SELECTOR: Recurrent sweep, single sweep, CW, and external on panel switch.

CONTROL: Single sweep, triggered by panel button, or external positive going signal 20 volts or greater.

SWEEP WIDTH: Continuously adjustable from 0 to any part of entire frequency range.

TIME: 100 to .01 seconds.

MONITOR OUTPUT: Positive linear sawtooth, 45 volts peak; Blanking out, 75 volts negative.

EXTERNAL SWEEP: 200 volts gives full sweep width.

AMPLITUDE MODULATION

INTERNAL SQUARE WAVE: RF output alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps.

EXTERNAL: 30 volts maximum signal increases RF output from 0 to maximum.

POWER INPUT: 105 to 125 volts; 60 cps.

Write us for complete details of these new oscillators. We'll also send you our new short form catalog, which describes Alfred's complete line of packaged traveling wave tube amplifiers.

ALFRED ELECTRONICS

897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

3

High Efficiency Stub Antenna...
another design problem solved by HRB-SINGER

Among HRB's most recent developments in the area of antenna design is the unusual and outstanding tunable stub antenna. This extra-sturdy antenna is truly omni-directional in the horizontal plane. Used in conjunction with UHF transmitter receivers, its prime application is in aircraft and missile telemetry. Its capacity to remain unaffected by extremely high altitudes and its wide range tunability make it ideal for application in missile tracking.

The tunable stub antenna represents only one of the many major developments brought about through the designing of antennas to meet specific customer requirements and applications. Years of experience in the development of these highly complex and versatile antenna designs provide a diversified capability to solve your specific antenna problem. Investigate by writing Dept. E-10. Informative literature describing the HRB-Singer antenna capability is yours for the asking.

ELECTRONIC RESEARCH AND DEVELOPMENT in the areas of:
Communications • Countermeasures • Reconnaissance • Operations Research • Human Factors • Intelligence • Weapons Systems Studies and Analysis • Nuclear Physics • Astrophysics • Antenna Systems

HRB
HRB-SINGER, INC.
A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY
Science Park, State College, Pa.
SINGER MILITARY PRODUCTS DIVISION

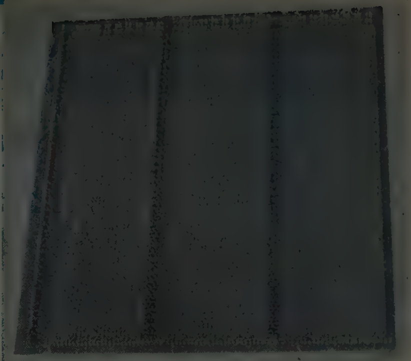
Industrial Engineering Notes

(Continued from page 102A)

also has been outstanding. The total employed in electronic manufacturing is now estimated in excess of 760,000. This is more than double employment in the industry at the start of the decade. Every state in the union and the District of Columbia now have at least one electronic plant, although more than half the industry's manufacturing employment is in the six states of New York, Pennsylvania, New Jersey, Massachusetts, Illinois, and California. The chances now appear to be excellent that 1959 factory sales records will be surpassed in 1960 in all of the industry's principal product categories. On the basis of studies by the EIA Marketing Data Department, a total 1960 sales forecast of $10.35 billion now seems to be justified. This would represent a 12½ per cent increase over the record highs of 1959. The increasing importance of the industry in the nation's program of defense production was demonstrated by the substantial rise in military product sales during 1959 in the face of a general levelling off of total defense procurement. The electronic content of military hardware has risen steadily during the decade. It now stands at about 33 per cent of total defense procurement and can be expected to increase fairly substantially next year. The consumer segment of the industry, manufacturers of its oldest line of products, showed real vitality in snapping back from a $100 million decline during the recession year of 1958 to set a new all-time high with a 28 per cent sales increase. Gains were achieved in each of the main consumer product categories, both in units sold and sales dollars, with radio manufacturers enjoying their best year since the post-war boom of the late 1940s. It is anticipated that growing public awareness of the availability of extremely high quality home-reproduced music will contribute significantly to an increase of more than 10 per cent in consumer business for 1960. The electronic replacement business, it is believed, can look forward to an improvement in 1960 sales comparable to that of this year. This will reflect increases in the quantity of original equipment in use rather than any change in quality of products which, in fact, are steadily being made more reliable. The immediate and long-term future for industrial electronics looks particularly bright. For one thing, we have just begun to scratch the surface of market potentials in that portion of the industrial field represented by electronic computation and data processing. Experience with computers for the control of processes in petroleum refining and the production of chemicals, cement, and electric power foreshadows widespread use of similar equipment, within relatively few years, as a route to higher industrial operating efficiencies. Moreover, I am confident that, within the next decade, we shall see computers employed by business management for the making and execution of decisions to an extent undreamed of today. It has been recognized for some time that

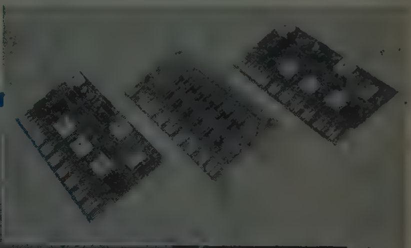
(Continued on page 106A)

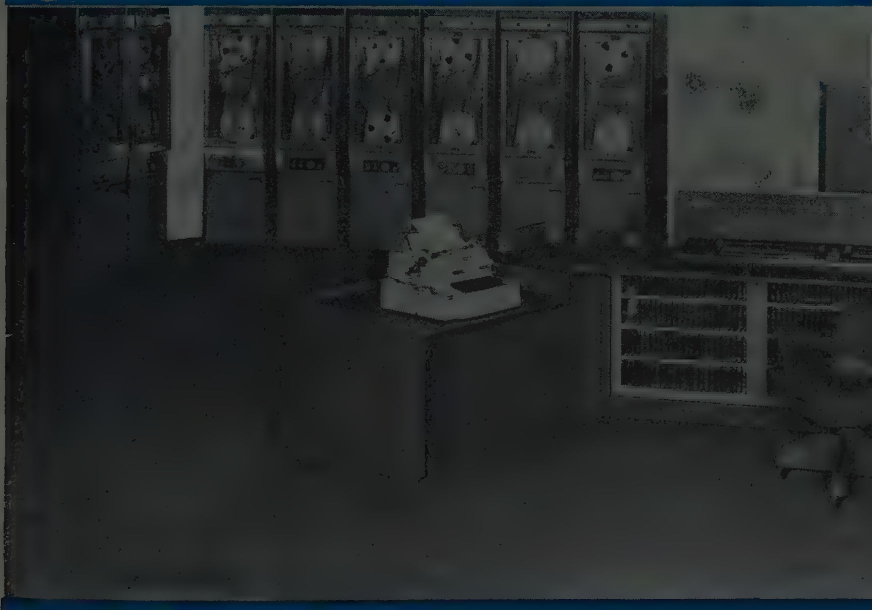
For Its 2000 Computer... PHILCO specified ELCO VARICON connectors



Front panel of matrix, shown with Elco Varicon contacts and guides.

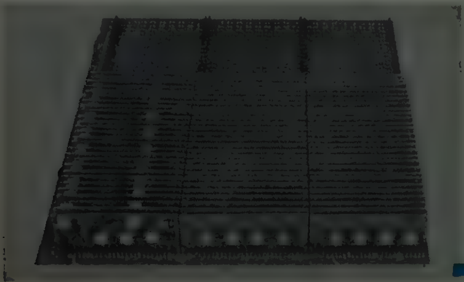
Plug-in modules, shown with Elco Varicon contacts.





PHILCO, one of the world's leaders, demanded reliability, design versatility and production ease in the contact selected for the very "heart" of its Input-Output Processor—the matrix panel. And that is why PHILCO selected ELCO's Series 5201, from our Series 5000 board-to-board printed circuit Varicon connectors! Furnished on disposable plastic strips, these fork-like contacts with 4 mating coined surfaces, not only act as electrical contacts providing 352 switching lines when staked to the boards, but also as retaining devices to hold modules in position on the matrix. Interesting? No, astounding! Write for Bulletin 108A and our complete Catalogs—just to prove: if it's new, if it's news, it's from ELCO!

Plug-in module, shown mounted on matrix panel utilizing Elco Varicon contacts.



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NEW HIGH POWER PULSE OSCILLATOR PG-650-C

The successful introduction of the PG-650 Pulsed oscillator to many test applications has led to an improved model of interest to workers in ultrasonics, r.f. transient analysis, nuclear magnetic resonance, etc. The following characteristics and features are available only with the PG-650-C.

Frequency Coverage 5-90 MC in 7 ranges*

Frequency Coverage	5-90 MC in 7 ranges*
R.F. output Voltage (Min.) into 93 ohms	0-300 p. to p.
Pulse length continuously variable	1½-15 µsec
Rise and Fall times (Max.)	0.5 µsec
Pulse Drop	5% Max.
Noise Output between Pulses	Thermal Noise from Termination
Harmonic Content (Max.) mostly 3rd	10%
R.F. Leakage	Negligible
Trigger to Pulse Jitter	.005 µsec
P.R.F. External	0-3000 cps
P.R.F. Internal	50-2500 locking on 60
Pulse to Pulse Jitter (Max.)	.005 µsec

SPECIAL FEATURES

Pulse lengths available from ½ to 50 µsec

Internal Delay Ranges available from calibrated Helipot .... 200, 1100, 11,000 µsec

Gate Pulse output available for intensifying and blanking purposes.

External modulation of r.f. oscillator using varying pulse lengths and p.r.f.'s for Carr Purcell Method. Fine controls of P.R.F., Pulse length, and delay times.

Usable as C.W. Oscillator or Pulsed Amplifier.

* Special coils will extend coverage from 0.5 to 150 MC.

Please write for our bulletins on other test equipment: Wide Band Amplifiers, Preamplifiers, and Precision Attenuators.

Arenberg Ultrasonic Laboratory, Inc.
94 Green Street, Jamaica Plain 30, Mass.
Phone: JAmaica 2-8640

Industrial Engineering Notes

(Continued from page 104A)

electronics will have a vital and exciting part in man's efforts to conquer space. This role recently was expressed in terms of future business in an EIA Marketing Data Department study. It showed hardware for non-military space applications approaching $100 million last year and increasing more than eightfold by the end of 1970. A major growth factor in space electronics will be the development of new and better satellites for communications and other purposes which are certain to be produced successfully despite recent rocket failures and other setbacks. It is now generally recognized that, in venturing into space, the electronics industry has had to meet standards of reliability well above those which proved to be acceptable in more conventional undertakings. Improvements in this direction are certain to be adopted by the industry generally with the result that, in a few years, better and more desirable products will be available throughout the entire electronics line. This cannot fail to be stimulating to the industry. Perhaps even more significant growth can be anticipated from a high level of research activity and product development. In view of this industry's favorable position with respect to progress in space and its record of scientific achievement, a $20-billion-a-year business in electronics by the end of 1970 does not seem unrealistic.

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Professional Group Meetings

AERONAUTICAL AND NAVIGATIONAL ELECTRONICS

Oklahoma City—December 16, 1958

"Ferrite Load Isolators," J. Winchels, CAA.

"Radar Microwave Link," H. J. Burton CAA.

Oklahoma City—February 10

"Electrical Systems for Jet-Powered Transport Aircraft," C. L. Daniels, FAA Aeronautical Center.

Oklahoma City—February 18

"The Application of Dielectric Materials to Microwave Absorbers and Luneberg Lenses," E. F. Buckley, Emerson and Cuming, Inc.

Oklahoma City—April 21

"Pancake VOR—Latest Developments," E. Foster.

Oklahoma City—June 9

"FAA Long Range Radar," G. McKinnis.

Oklahoma City—October 27

"GEEIA—Rapcon Pre-Engineering—TACAN," B. Williams, A. Ranscher, J. F. Maser, All of Tinker AFB.

ANTENNAS AND PROPAGATION

Boston—October 29

"Correlation Techniques Applied to Antenna Pattern Control," H. E. Band—J. E. Walsh, Pickard and Burns.

Boston—November 16

"Tetragon Antennas," M. L. Rosenthal, General Electronic Lab.

"VHF Signal Level Measurements Along A 2,000 Mile Path," A. S. Orange, Air Force Cambridge Res. Center.

Boston—December 15

"Antenna System For The Harvard Meteor Radar Project," A. K. Rodman, Radiation Engineering Lab.

"Radio Technique Employed In The Study of Meteors," W. H. McDonough, Harvard College Obs.

Los Angeles—September 10

"Analysis and Prediction of Radio Signal Interference Effects Due to Ionized Layer Around A Re-Entry Vehicle," W. C. Taylor, Lockheed Missile and Space Div.

Los Angeles—November 12

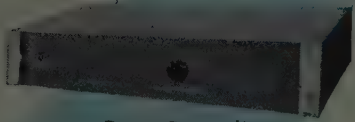
"Plasma Reactions on Electromagnetic Waves," Tutorial Presentation, R. S. Elliot, UCLA.

(Continued on page 108A)

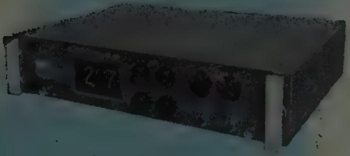
LIKE WORDS IN A SENTENCE...

CUBIC DIGITAL SYSTEMS

SPEAK FOR THEMSELVES!

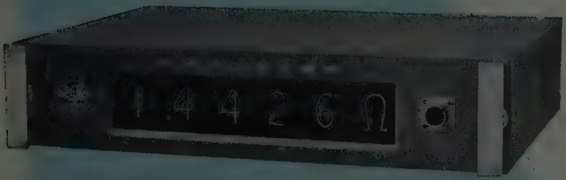


Data Recording

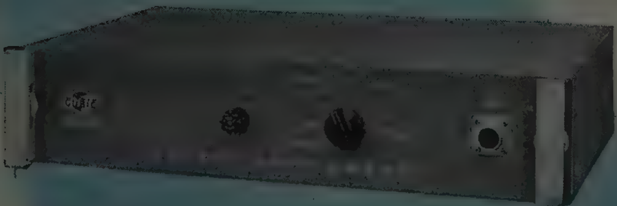


Input Sampling

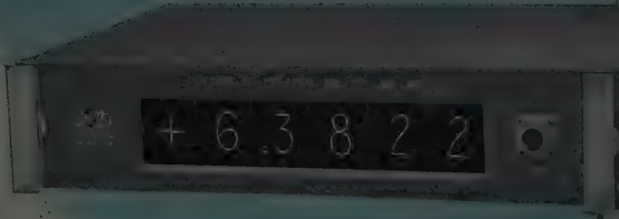
Voltage Ratio Measurement



Resistance Measurement



AC Voltage Measurement



DC Voltage Measurement

Standard-size Cubic Digital Instruments, with modular construction of plug-in units, make for easy development of sophisticated digital systems from standard off-the-shelf instruments. Wiring of systems is between *cases*, and the release of front-panel locking knobs permits the unit to slide out. Simple or complex systems for measurement and recording are quickly, easily available from Cubic, offering "digital systems that design themselves."

And, of course, Cubic quality speaks for itself, too, with such unique features as "controlled drive" stepping switches which swing up and out for ease of routine maintenance. From front panel to rear connector panel, Cubic's is *the superior* digital instrument.

NEW FROM CUBIC . . . the Talking Meter, instrumentation that really *does* speak for itself, with measurements or other parameters reported to the ear by a clear human voice.

Years-ahead engineering, factory production techniques inspired by pride in the end result, careful quality control and reliability testing . . . all these factors make Cubic's the truly fine instrumentation . . . Digital Systems that speak for themselves.

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INDUSTRIAL DIVISION
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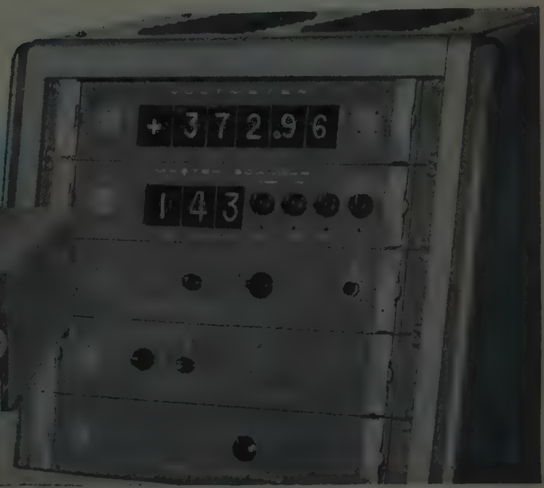
Electronic Engineering With a Dimension for the Future



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Professional Group Meetings

(Continued from page 106A)

AUDIO

Baltimore—December 14

"A New Method or Elimination of Turntable Rumble, Wow and Flutter," P. Weathers, Weathers Ind.

Boston—November 12

"Frequency Fidelity in Audio Systems," C. I. Malme, R.L.E., M.I.T.

AUTOMATIC CONTROL

Milwaukee—October 20

"Optimizing the Transient Performance of A Pneumatic Temperature Control System," J. P. Metzger, Milwaukee School of Engineering.

BROADCASTING

Fla. West Coast—November 18

"Communications at a Strategic Air Command Base," W. E. Smith, U. S. Air Force, McDill Air Force Base.

Philadelphia—December 10

"A Report on Field Tests," E. M. Creamer, Jr., Philco Corp.

CIRCUIT THEORY

Los Angeles—December 15

"Parametric Amplifiers," A. D. Berk, Hughes Aircraft Co.

"Inertial Navigation" R. S. Carlson, Autonetics Div., North American Aviation.

Philadelphia—October 26

"Introduction to Active Circuits," B. K. Kinariwala, Bell Telephone Labs.

Philadelphia—November 2

"Single and Multiple Port Active Devices," J. Hilibrand, RCA Labs.

Philadelphia—November 9

"Impedance Properties of Active Networks," J. H. Mulligan, Jr., New York Univ.

Philadelphia—Nov. 16

"Non-Reciprocal Networks," H. J. Carlin, Institute of Brooklyn.

Philadelphia—November 30

"Theory of Parametric Amplifiers," K. K. N. Chang, RCA Labs.

Philadelphia—December 7

"Masers, Low-Noise Systems, and Possible Future Developments," R. H. Kingston, Lincoln Lab.

(Continued on page 110A)

SPECIAL DESIGNS

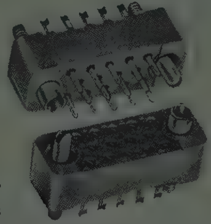
Our engineering department will be glad to design types to your exact specifications. Send us your requirements for analysis.

SERIES 40

PRINTED CIRCUIT*

Features exclusive "Bellowform" Contacts and is available in 6 to 58 single or double row contacts. Various types for 1/16", 3/32", and 1/8" printed circuit boards. Wiring styles include eyelet lug for soldering, solderless wire wrap, taper pin solderless wiring, and contacts for dip soldering.

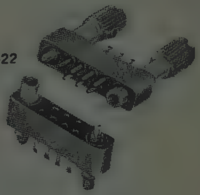
*PAT. NO. 2,875,425



SERIES 20

MINIATURE

A compact, lightweight connector available with a wide range of contacts from 4 to 104. Types available with coaxial contacts—50-ohm or 70-ohm matched impedance, hoods and protective shells.

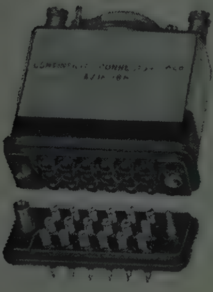


SERIES MM-22

MICRO-MINIATURE

Ultra miniaturization without performance loss. Ruggedized to withstand shock and vibration extremes. Available with 5, 7, 9, 11, 14, 20, 26, 29, 34 and 44 contacts for #22 AWG wire. 3 amps, 1800V RMS.

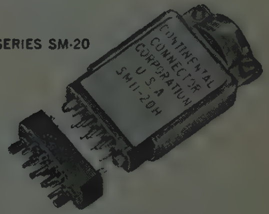
PRECISION CONTINENTAL CONNECTORS



SERIES E-Z, 14 & 16

POWER

Available in 12, 18, 24 and 34 contacts for #16 or #12 AWG wire or taper pin for solderless wiring. Spring loaded pin contacts for quick release. Supplied with polarizing screwlocks or standard guide pin and socket.



SERIES SM-20

SUB-MINIATURE

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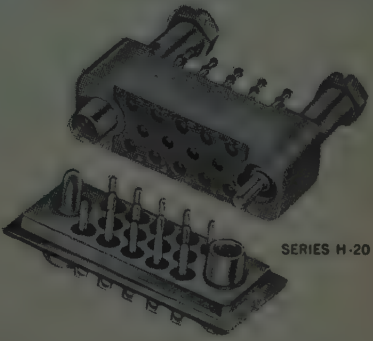

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Professional Group Meetings

(Continued from page 108A)

COMMUNICATION SYSTEMS

Oklahoma City—November 19

"U. S. Air Force Sage, (Semi Automatic Ground Environment)," Maj. Holt and Maj. Peel, U. S. Air Force, and I. White, Western Electric Co.

ELECTRON DEVICES

Boston—November 24

"Electron Devices in Particle Accelerations," E. T. Westbrook, High Voltage Engineering.

Washington, D. C.—November 23

"The Practical Utilization of Microwave Energy for Microwave Propulsion," W. C. Brown and M. Theodore, Raytheon.

ELECTRONIC COMPUTERS

Akron—December 15

"Microwave Computers," F. Sterzer, RCA.

Baltimore—December 16

"Analog to Digital Conversion Techniques," K. Bacon, United Aircraft Corp.

Houston—November 25

"Some Maniacs I Have Known," N. Metropolis, Univ. of Chicago.

Houston—December 15

"Rice Institute Computer," M. Graham, Rice Inst.

Los Angeles—September 30

"Computer Technology in Russia," W. H. Ware, The RAND Corp.

"Computer Technology in Russia," P. Armer, The RAND Corp.

Los Angeles—October 22

"Paran and its Applications," Y. Hata, Kanamatsu New York Inc.

Los Angeles—November 19

"The Honeywell 800 System," D. E. Robinson, Datamatic Div. of Minneapolis Honeywell.

Los Angeles—December 17

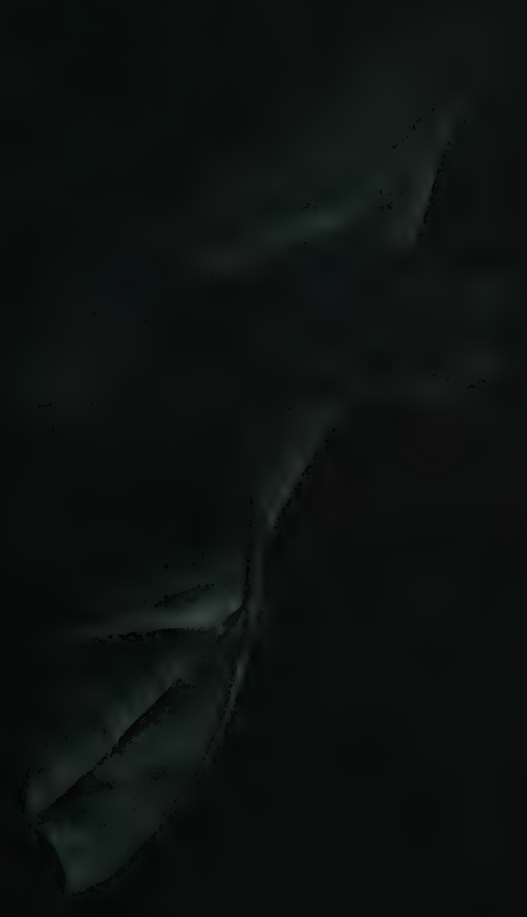
"The Kerr Effect in Ferromagnetic Research" D. Treves, Weizman Institute of Science.

"Vacuum Evaporated Information Processing Subsystems," K. D. Broadbeat, Hughes Research Labs.

San Francisco—November 24

"Computer Activities in Japan," E. Goto, Tokyo Univ.

(Continued on page 112A)



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Professional Group Meetings

(Continued from page 110A)

San Francisco—December 15

"Circuit Philosophy and Design for the new ILLIAC Computer," W. Poppelhaum, Univ. of Illinois.

ENGINEERING MANAGEMENT

Boston—December 3

"The Incident Process," P. Pigors, M.I.T.

San Francisco—December 8

"Problems in Research and Development Management," J. Church, Booz, Allen, and Hamilton.

ENGINEERING WRITING AND SPEECH

Los Angeles—September 17–18

Third National Symposium.

Los Angeles—November 19

"Specification Writing," R. Norton, Hughes Aircraft Co.

INDUSTRIAL ELECTRONICS

Omaha-Lincoln—November 20

Demonstration of Braille Multimeter, Sliderule, and Stylus Notes, La Von Peterson.

Demonstration of 9,000 RCA Panels, and Tour of Radio Engrg. Inst., Chief Instructor R. L. Hill, and L. Kozicki and L. Sedlak.

INFORMATION THEORY

Los Angeles—December 15

"Statistical Mechanics and Information Entropy," J. M. Richardson, Hughes Aircraft Co.

INSTRUMENTATION

Long Island—November 17

"Instrumentation in Oceanography," R. L. Erath, Grumman Aircraft Corp.

Los Angeles—December 2

"Radiation Instrumentation Techniques," L. Gardner, Litton Ind.

Washington—November 16

"Design of an RC Filter for use at Very Low Frequencies," W. S. Campbell, David Taylor Model Basin.

"A Telemetering Torque and Horsepower Meter," M. W. Wilson, David Taylor Model Basin.

Washington—December 21

"An R. F. Voltage Standard for Receiver Calibration in the Frequency Range of From 2 to 1000 Megacycles," G. V. Sorger and A. L. Hedrich, Weinschell Engineering Co., Inc.

MEDICAL ELECTRONICS

Los Angeles—December 10

"The Coding of Information in the Central Nervous System," W. R. Adey, U.C.L.A.

Montreal—November 25

"Engineering in Medicine," J. Hopps, National Research Council.

Washington—December 3

"Physiological Instrumentation for Space Flight," W. Greatbatch, Taber Instrument Corp.

MICROWAVE THEORY AND TECHNIQUES

Baltimore—December 9

"Useful Propagation of Microwaves Well Beyond the Horizon," T. J. Carroll, Bendix Radio Div.

Boston—October 21

"Microwave Properties of Thin Magnetic Films," P. Tannenwald, Lincoln Lab.

Boston—December 9

"Fundamental Properties of Parametric Amplifiers," P. Johannessen, Sylvania Co.

Los Angeles—December 10

"Survey of Parametric Amplifier Research at SRI," Stanford Res. Inst.

Omaha-Lincoln—December 3

"Radar Scattering From Certain Periodic Discontinuities," E. D. Denman, Midwest Research Inst.

San Francisco—December 2

"Microwave Generation Using Ferrites," J. Shaw, Stanford Univ.

Washington—December 8

"Microwave Directional Filters (striplines)," L. P. Tuttle, Jr., Melpar Inc.

MILITARY ELECTRONICS

Indianapolis—October 29

"Responsibilities in Electronics," G. R. Fraser, U. S. Naval Avionics Facility.

San Diego—December 16

"Flight Safety Criteria at the Atlantic Missile Range as Related to the Atlas V & D Missile System Configuration," S. L. Ackerman, Electronic Products of Convair Astronautics.

NUCLEAR SCIENCE

Oak Ridge—December 17

"Electron Energy Concepts in Electronics," J. L. Blankenship, Oak Ridge National Lab.

(Continued on page 114A)

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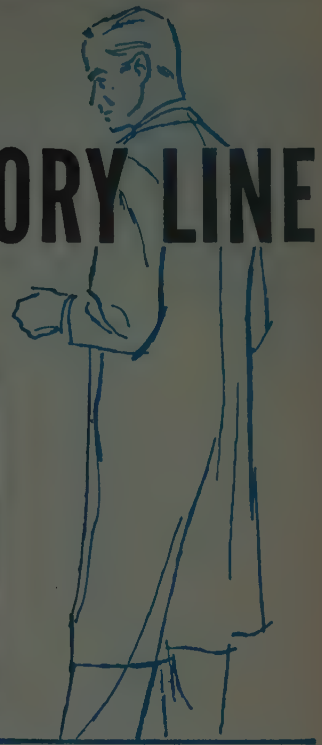

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Professional Group Meetings

(Continued from page 112A)

PRODUCTION TECHNIQUES

Boston—November 30

"A Comparison of U. S. and European Components and Techniques," L. Kahn, Aerovox Corp.

RELIABILITY AND QUALITY CONTROL

Fort Worth—November 10

"Component Quality Assurance and Reliability Programs," A. W. Wortham, Texas Instruments, Inc.

Los Angeles—November 16

Panel—"Reliability Engineering Training," E. P. Coleman, U.C.L.A.

Panel—"Reliability Engineering Training," H. G. Romig, Hoffman Labs.—R & D.

Panel—Summary by I. Doshay (moderator).

SPACE ELECTRONICS AND TELEMETRY

Detroit—December 2

"New Advances in Telemetry," Dr. Epstein, Tele-Dynamics Inc.

(Continued on page 116A)

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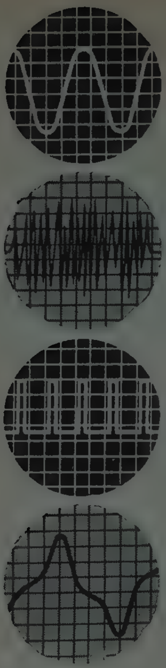

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Professional Group Meetings

(Continued from page 114A)

Los Angeles—October 20

"Aspects of the Digilock Telemetry System," D. W. Boensel, Space Electronics Corp.

Los Angeles—November 17

"Explorer VI Telemetry—Telebit," R. E. Gottfried, Space Tech. Labs.

VEHICULAR COMMUNICATIONS

Los Angeles—November 19

"Precision Measurements with Heterodyne Meters," R. Boniarz, Gertsch Co.

Tape Recorded Report on Geneva Conf., Kittner and Watkins.

Los Angeles—December 17

"Transistorized Mobile Receivers," V. Stineman, General Electric Co.

Section Meetings

AKRON

"A New Radio Interferometer Tracking System," Dr. C. H. Grace, Smith Electronics, Inc. 11/17/59.

"Methods of Continuous Radar Performance Monitoring," L. H. Fisher, Polytechnic Research & Development Co. 12/8/59.

ATLANTA

"Visual and Acoustical Research at Murray Hill," Dr. E. E. David, Jr., Bell Telephone Laboratories. 1/4/60.

BALTIMORE

"A New Approach to the Elimination of Turntable Rumble, Wow and Flutter," Paul Weathers, Weather Industries. 12/14,59.

"Molecular Engineering," Dr. Gene Strull, Westinghouse Electric Corp. 1/11/60.

BENELUX

"The Development of Color Television in the United States," Dr. G. H. Brown, RCA, 11/10/59.

BINGHAMTON

"Industry's Future in National Defense," George Metcalf, General Electric Co. Plant tour of the General Electric Johnson City facilities. 11/17/59.

"Status of Electronic Microminiaturization," N. J. Doctor, National Bureau of Standards. 1/11/60.

BUFFALO-NIAGARA

"Automatic Car Controls," R. S. Cataldo, General Motors. 9/16/59.

"Education for the Electronic Age," Dr. Ernst Weber, IRE President. 10/6/59.

"Threshold Sensitivity of Radar Display Devices," Dr. Carl Miller, Cornell Aeronautical Labs. 12/17/59.

(Continued on page 118A)

Appointment: Countermeasures

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Section Meetings

(Continued from page 116A)

CEDAR RAPIDS

"New Developments in Color Vision," Dr. W. L. Hughes, Iowa State University. 11/11/59.

"Ten Years Before the Masthead," E. K. Gannett, IRE Editor; "Theory and Application of Tunnel Diodes," Drs. A. V. Pohm and R. Mattson, Iowa State University. 12/10/59.

CENTRAL FLORIDA

"Polaris Missile," Rear Adm. Raborn, U. S. Naval Office in Washington. 10/15/59.

"Engineering Curriculum and Accreditation," Dr. J. Kueper, Brevard Engineering College. Tour of Melbourne Telephone Exchange and Microwave Relay System with comments by M. R. Hardt, Southern Bell Telephone Co. 11/27/59.

"Bio Effect and Need for Better Scientific Communication," Col. G. Knauf, Patrick AFB. Election of officers for 1960. 12/17/59.

CINCINNATI

"Twenty Years with Radio-Controlled Model Planes," Dr. W. A. Good, Johns Hopkins University: "Mission Considerations for Nuclear Propulsion of Aircraft and Missiles," A. A. Hafer, General Electric Co. 12/15/59.

CLEVELAND

"Theories of Stereophonic Sound, Demonstration," B. B. Bauer, CBS Laboratories. 12/10/59.

"Silicon Controlled Rectifiers and Applications," E. W. Hookway, G. E. Co. 12/17/59.

COLUMBUS

"Recent Developments in Maser Amplifiers," Dr. W. S. C. Chang, Ohio State University. 1/12/60.

ELMIRA-CORNING

"Microelectronic Computer Concepts Aimed at a Coming Revolution," Prof. E. W. Fletcher, MIT, 10/26/59.

"The Cleaning of Electronic Devices and Materials," F. J. Biondi, Bell Telephone Laboratories. 11/23/59.

"Cornell Radar Telescope," Dr. W. E. Gordon, Cornell University. 12/14/59.

EMPORIUM

Social Meeting—Ladies Night. 12/11/59.

FLORIDA WEST COAST

"Some of the Problems of Space Navigation," C. W. Benfield, Minneapolis-Honeywell Regulator Co. 12/16/59.

FORT HUACHUCA

"Computer Hardware," R. L. Manuel, IBM, 12/21/59.

FORT WORTH

"Telephone Science and National Defense," Glenn Scott, Southwestern Bell Telephone Company. 12/15/59.

GAINESVILLE

"Electronic Focusing of High Density Electron Beams," Dr. A. D. Sutherland, Sperry Electronic Tube Division. 1/13/60.

HAMILTON

"CN Telegraphs and Microwave," C. Bridgeland, Canadian National Telegraphs. 12/15/59.

HOUSTON

"The Rice Institute Computer," Dr. Martin Graham, The Rice Institute. 12/15/59.

(Continued on page 120A)

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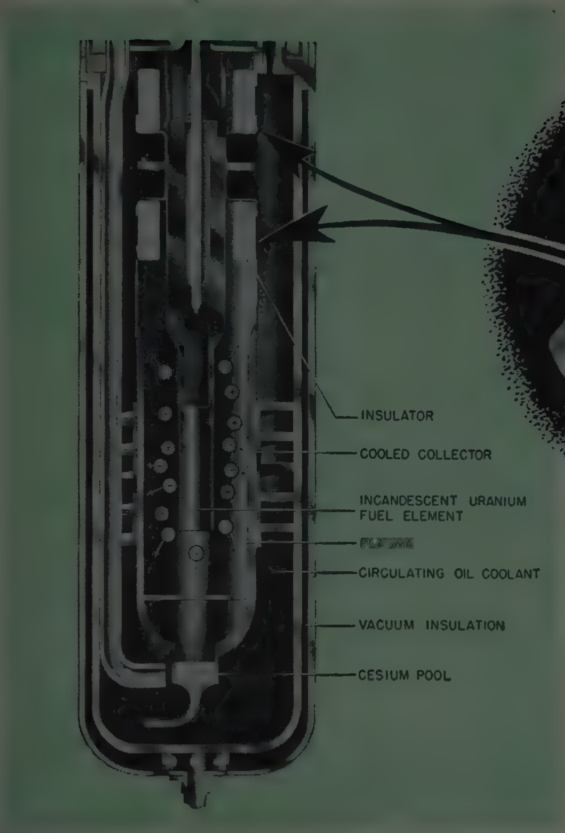

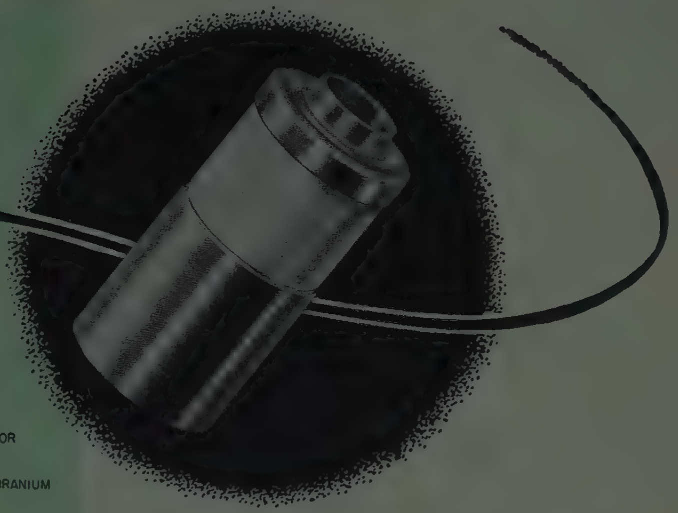

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Section Meetings

(Continued from page 118A)

HUNTSVILLE

"Airborne Bio-Medical Instrumentation," J. T. Powell, Redstone Arsenal. 12/14/59.

INDIANAPOLIS

"Precision Airborne Navigational Methods," J. F. Genna, U. S. Naval Avionics Facility. 1/15/60.

ITHACA

"The Van Allen Radiation Belts" Prof. T. Gold, Cornell University. 10/1/59.

"The Use of Weibull Probability Paper in Reliability Studies," John Kao, Cornell University. 11/5/59.

"Bandwidth Compression by Means of Vocoders," Frank Slaymaker, Stromberg-Carlson. 12/10/59.

LONG ISLAND

"Oceanography," Dr. J. B. Hersey, Woods Hole Oceanographic Institute. Movie "Washington At Work." 12/8/59.

LUBBOCK

Tour of Southwestern Bell Telephone Company plant. 12/22/59.

MILWAUKEE

"Solid State Circuits," Harvey Cragon and Charles Phipps, Texas Instruments. 10/20/59.

"Crystals in Yesterday's Beauties and Today's Technology," Alan Holden, Bell Telephone Labs Inc. 11/4/59.

"An Introduction to Single Sideband," E. W. Pappentuss, Collins Radio Co. 12/15/59.

MONTREAL

"Transistor Logic Circuits," T. G. Rankin, Sperry Gyroscope Co. of Canada. 12/16/59.

NEW YORK

"The Simulation of Learning Processes," A. G. Schillinger, Polytechnic Institute of Brooklyn. 11/4/59.

NORTHERN ALBERTA

"Selective Signalling for Mobile Telephone Systems," R. Usher, Alberta Government Telephones. 12/7/59.

PHOENIX

"The Moscow IGY Conference," Dr. H. Richter, Convair Astronautics. 12/15/59.

PRINCETON

"The Practical Utilization of Power Transmission by Electromagnetic Means," Dr. W. C. Brown, Raytheon. 12/10/59.

OKLAHOMA CITY

Tour of the Sylvania Tube Plant, Shawnee, Oklahoma. 11/10/59.

"Dew Line," Dr. C. A. Dunn, Oklahoma State University. 12/8/59.

SAN DIEGO

"Interplanetary Travel," K. J. Bossart, Convair Astronautics. 12/2/59.

SCHENECTADY

"The Future of Engineering Education," Prof. H. W. Bibber, Union College and Prof. W. R. Beam, R. P. I. 12/8/59.

"Electrically Steered Antennas Using Ferrite," Harold Shnitkin, W. L. Maxson Corp. 1/12/60.

(Continued on page 124A)

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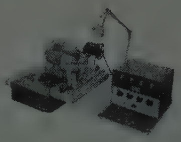
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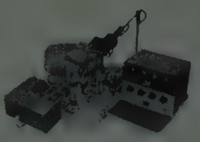
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Section Meetings

(Continued from page 120A)

SYRACUSE

"Engineering, Past and Present," Dr. J. W. McRae, American Telephone & Telegraph Co. 12/14/59.

TOLEDO

Tour of RCA Transistor Mfg. Plant, Findlay, Ohio. 12/9/59.

TUCSON

"Applications of Tunnel Diode," John Wentworth, RCA 12/11/59.

TWIN CITIES

"FM Multiplex," A. H. Bott, RCA. 12/16/59.

WASHINGTON

"The Challenging Race for New Products," H. L. Vincent, Jr., Booz, Allen & Hamilton. 12/7/59.

WESTERN MASSACHUSETTS

"On Quantifying the Electrical Activity of Nervous Systems," Dr. T. H. Sandel, MIT Lincoln Laboratory. 12/4/59.

WICHITA

"Use of Radar in Weather Forecasting and Research," Ellis Pike, Wichita Weather Bureau. 9/16/59.

"A Review of Radar Fundamentals, Techniques, and Applications," Wayne Carver, Boeing Airplane Co. 10/21/59.

"A Historical Survey of Electrical Communications," Dr. ZVI Prihar, University of Wichita. 11/18/59.

SUBSECTIONS

BUENAVENTURA

"A Discussion of Interferometry vs Pulse Radar Techniques for Tracking Artificial Earth Satellites and Ballistic Missiles," E. "CW" King Stodola, Reeves Industrial Corp., and W. J. Thompson, Cubic Corp. 12/9/59.

EASTERN NORTH CAROLINA

"Development and Design of Saturable Core Power Inverters for Transistor Circuit Application," C. M. Bailey, Jr., Bell Laboratories. 12/11/59.

GAINESVILLE

"The Satellite Communications Age," G. S. Shaw, Radiation, Inc. 9/23/59.

LANCASTER

"The Confining Field System for a Nuclear Fusion Machine," A. L. Mozina, Allis-Chalmers. 10/21/59.

"Engineering Aspects of the RCA 501 Computing System," H. Kleinberg, RCA. 11/16/59.

MID-HUDSON

"Wall Street Looks at Electronics," Miss Peggy Schulder, Merrill Lynch, Pierce, Fenner & Smith. 11/24/59.

"Better Design and More Profits Through Value Analysis," Glenn Hart, GE Co. 12/9/59.

NORTHERN VERMONT

"Recent Developments in the Field of Radar," Lt. R. G. Eldridge, MIT Lincoln Lab. 10/26/59.

"Present Trends in Semiconductor Device and Materials Research," Dr. R. E. Halsted, G. E. Co. 11/23/59.

(Continued on page 126A)

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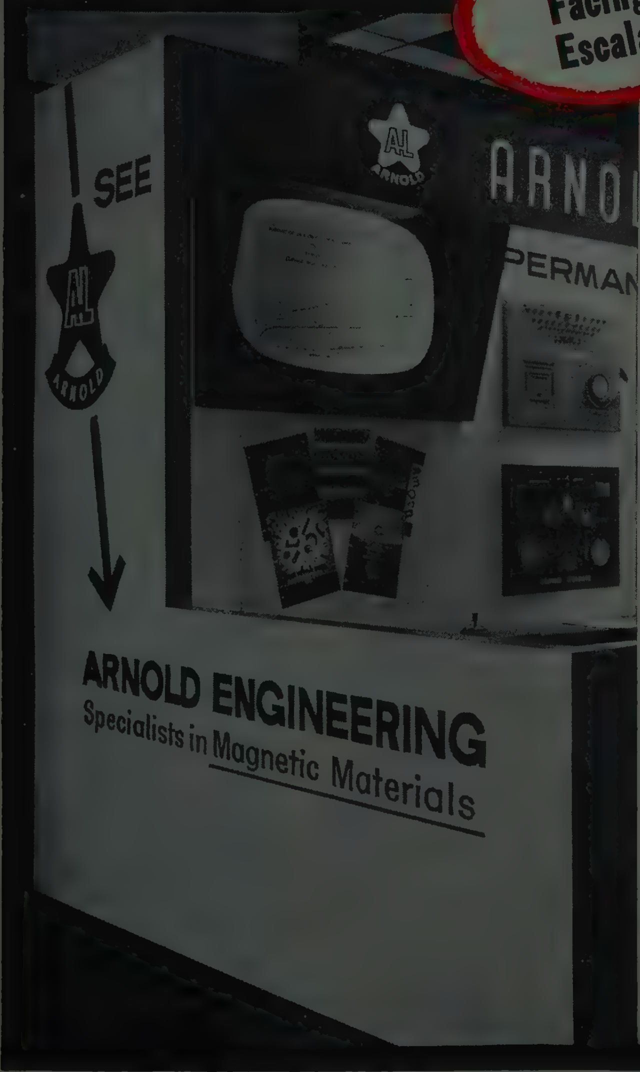
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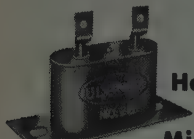

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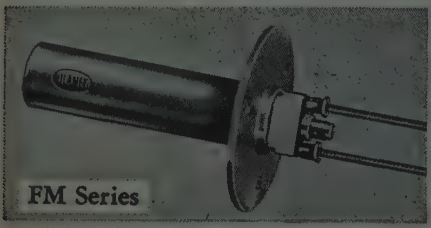

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Section Meetings

(Continued from page 124A)

PASADENA

"Earth Satellite Instrumentation—Explorer VI," John Taber, Space Technology Labs. 9/8/59.

"Radio Astronomy," Prof. A. C. B. Lovell, University of Manchester, England. 10/1/59.

SANTA BARBARA

"Realities in Reliability," John Moore, North American Aviation. 12/15/59.

SOUTHWESTERN ONTARIO

"Read Out Methods on Cathode Ray Oscilloscopes—Model 2610," R. Wilton, OBE, Bach Simpson, London. 11/30/59.

WESTCHESTER COUNTY

"The Electromagnetic Pinch Effect as a Space Propulsion Engine," A. E. Kunen, Republic Aviation. 11/18/59.

Membership

The following transfers and admissions have been approved and are now effective:

Transfer to Senior Member

Antony, C., Sunnyvale, Calif.
Beckwith, R. W., Fayetteville, N. Y.
Bellew, F. N., South Plainfield, N. J.
Booth, J. D., Catonsville, Md.
Cantrell, W. E., Ft. Worth, Tex.
Conklin, E. H., Charleston, S. C.
Davis, K. E., Portland, Ore.
Fink, E. A., Levittown, Pa.
Greefkes, J. A., Eindhoven, Netherlands
Grey, T. G., Mission, Kansas
Hager, K. F., Anchorage, Alaska
Harris, J. R., Morristown, N. J.
Hirashima, H. K., Cincinnati, Ohio
Johnson, R. A., Syracuse, N.Y.
Minnick R. C., Pasadena, Calif.
Montgomery, J. D., Jr., Montclair, Calif.
Ottobre, J. N., North Plainfield, N. J.
Reach, R. W., Jr., Sudbury, Mass.
Reilly, V. E., Eatontown, N. J.

Admission to Senior Member

Korman, M. M., Rehovoth, Israel
Segal, D. D., Washington, D.C.

Transfer to Member

Amster, G. S., Brooklyn, N. Y.
Ash, H. Q., Goodyear, Ariz.
Bederka, S. E., Sunnyvale, Calif.
Beebe, C. W., Chicago, Ill.
Blancke, T. B., Essex Fells, N. J.
Briskman, R. D., Alexandria, Va.
Eatough, E. C., Orange, Calif.
Egger, C. P., Baltimore, Md.
Elder, H. E., Bethlehem, Pa.
Engels, R. O., Cincinnati, Ohio
Engelson, B., Franklin Square, N. Y.
Fernald, R. A., Bedford, Mass.
Ferri, R. I., New York, N. Y.
Finegold, L., Los Angeles, Calif.
Flaharty, C. L., Denver, Colo.
Flattau, T., Williston Park, L. I., N. Y.
Flavin, M. A., Plainfield, N. J.
Fliegner, A. F., Piedmont, Calif.
Fouch, J. W., New York, N. Y.
Franke, R. T., Palo Alto, Calif.
Fulcher, J. A., Dayton, Ohio
Gage, L. W., Hackensack, N. J.
Gage, N. C., Chatsworth, Calif.
Galbraith, J. R., King of Prussia, Pa.
Gammill, R. A., Jr., Rockville, Md.
Gearn, G. R., Seattle, Wash.
Gibson, R. E., Danvers, Mass.
Ginters, F. A., Long Island City, N. Y.
Gleason, C. A., Palo Alto, Calif.
Goddard, A. A., Jr., Denver, Colo.
Grant, M. L., Ridgefield, Conn.
Gubbins, L. J., Utica, N. Y.
Haber, K. H., Whippany, N. J.
Haibt, L. H., Croton-on-Hudson, N. Y.
Halas, E., Windsor, Ont., Canada
Hanley, J. J., Lawrence, Mass.
Hargrove, P. E., Mountain View, Calif.
Harris, L. M., Alamogordo, N. M.
Hennis, R. B., Binghamton, N. Y.
Herke, F. P., Jr., Fort Wayne, Ind.
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Kliman, M., Glen Head, L. I., N. Y.
Knight, W. W., Liverpool, N. Y.
Kraft, R. W., Indianapolis, Ind.
La Bree, C. T., Baltimore, Md.
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(Continued on page 128A)

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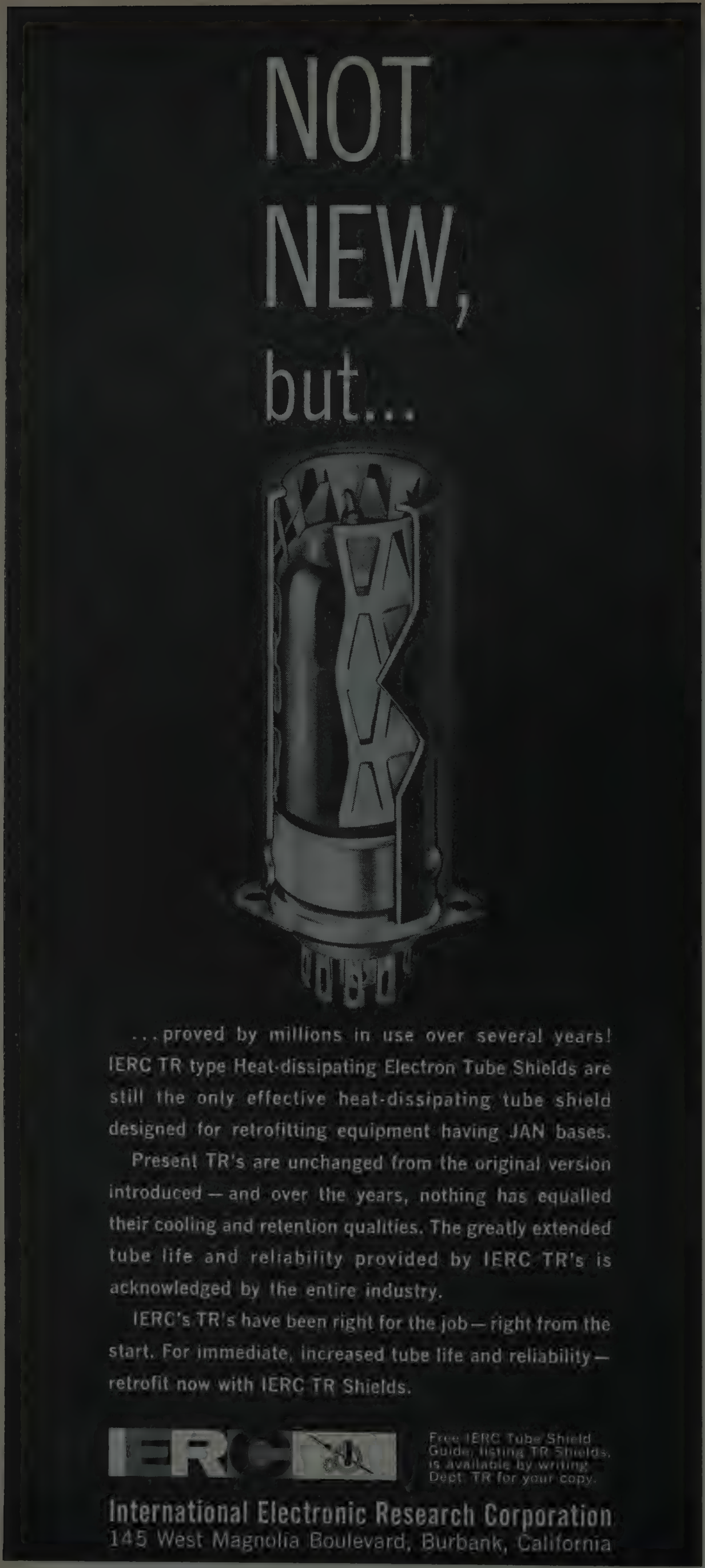

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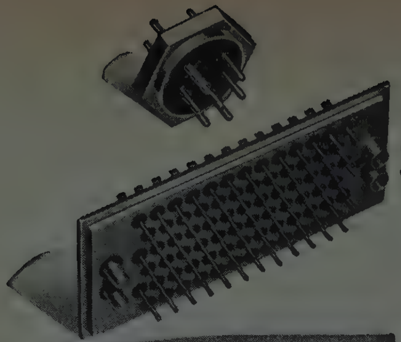

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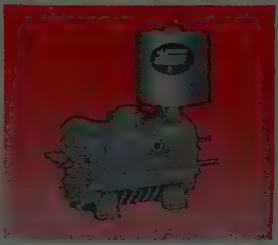

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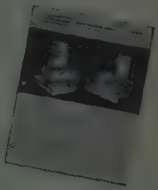

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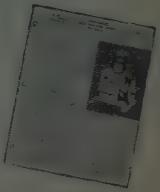

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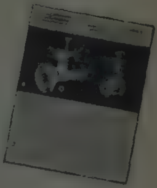

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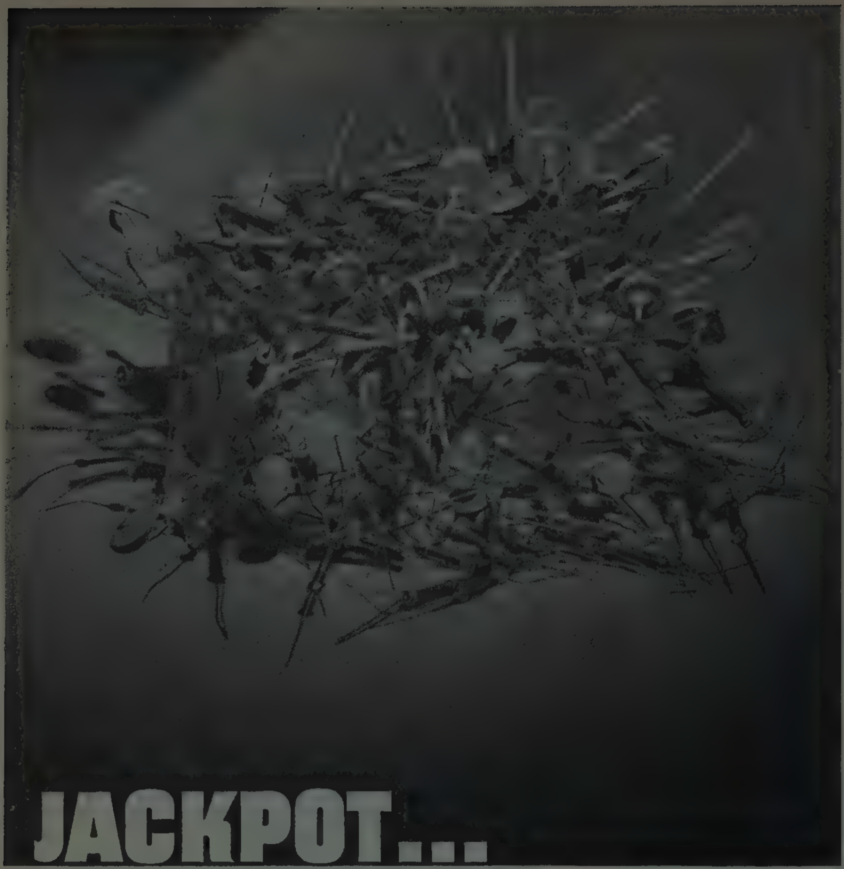

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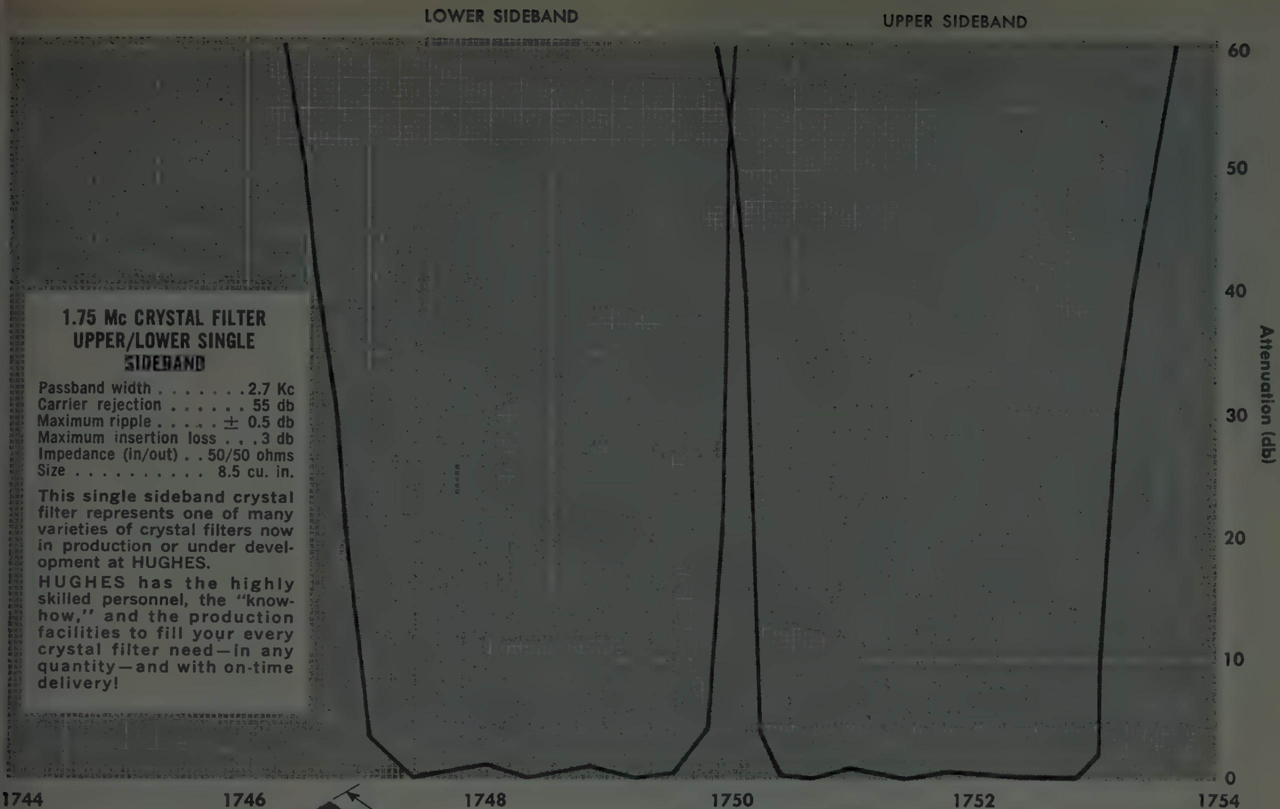
Pipkin, R. F. X., Baltimore, Md.
Pomerantz, R., Kingston, N. Y.
Poulos, E., Hicksville, L. I., N. Y.
Power, R. L., Littlerock, Calif.
Puigdollers, E., Jr., Levittown, Pa.
Randt, R. C., Haddonfield, N. J.
Rao, C. H., Secunderabad, India
Rhodes, R. M., Lebanon, N. J.
Riffenburg, R. E., Woodstock, N. Y.
Robb, H. E., Jr., Elk Grove Village, Ill.
Brother Roch, C.F.X., Roxbury, Mass.
Rock, S. A. Brooklyn, N. Y.
Roth, J., Cuyahoga Falls, Ohio
Rousculp, P. J., Playa Del Rey, Calif.
Rudnick, S. L., Waban, Mass.
Russell, A. D., Medford, Mass.
Ryser, L. W., Washington, D. C.
Schimanke, O., New York, N. Y.
Schwartz, L., Philadelphia, Pa.
Seifert, L. I., Forest Hills, N. Y.
Sensale, C. J., Springfield, N. J.
Sharp, R. L., New York, N. Y.
Shepard, S. A., San Francisco, Calif.
Smith, W. E., Pennsauken, N. J.
Spain, R. F., Troy, Mich.
Spohrer, R. F., Crystal Springs, Miss.
Spurlock, E. M., Washington, D. C.
Stacy, I. F., Harrison, N. J.
Steigman, P., New York, N. Y.
Stein, P. J., Little Neck, N. Y.
Steiner, J. W., West Caldwell, N. J.
Steinhardt, L. R., Escondido, Calif.
Steinweg, D. H., Baltimore, Md.
Stephens, R. P., Washington, D. C.
Stewart, D. A., Utica, N. Y.
Sullivan, J. W., Hermosa Beach, Calif.
Szczech, R. W., Johnson City, N. Y.
Tallent, G. R., Lowell, Mass.
Tartara, P., Milano, Italy
Tate, R. V., Villanova, Pa.
Temmer, S. F., New York, N. Y.
Thwaites, K. W., Washington, D. C.
Tisdale, J. G., Syosset, L. I., N. Y.
Tucker, W. E., Austin, Tex.
Tuller, R. V., Albuquerque, N. M.
Tuomenoksa, L. S., Whippany, N. J.
Tupper, F. R., Jr., Derry, N. H.
Tuttle, J. W., East Cleveland, Ohio
Valentini, N., Rome, Italy
van Rees, G. A., Moreno, Buenos Aires, Argentina
Van Sickle, T. T., Ypsilanti, Mich.
Vasile, J. A., Belleville, Ill.
Volcansek, M. J., Jr., Dallas, Tex.
Walczy, R. J., Dayton, Ohio
Ward, G. M., Linthicum Heights, Md.
Webster, J. P., Overland Park, Kan.
Westmoreland, P. E., Houston, Tex.
Whitley, C. W., Charlotte, N. C.
Williams, P. R., East Syracuse, N. Y.
Wing, L. H., Kowloon, Hong Kong
Zachary, J. D., Washington, D. C.
Zanfi, M., Milanino, Italy
Zement, K. H., Rimouski, Que., Canada

(Continued on page 138A)

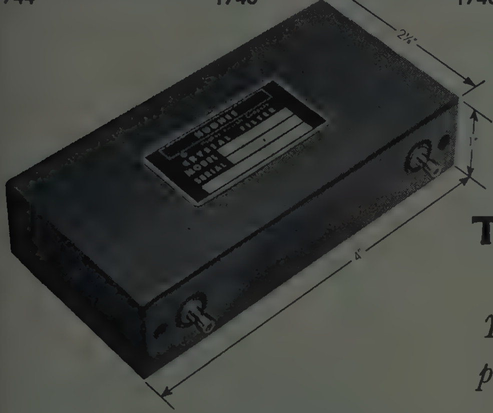


1.75 Mc CRYSTAL FILTER UPPER/LOWER SINGLE SIDEBAND

Passband width . . . . 2.7 Kc
Carrier rejection . . . . . . 55 db
Maximum ripple . . . . . ± 0.5 db
Maximum insertion loss . . . 3 db
Impedance (in/out) . . 50/50 ohms
Size . . . . 8.5 cu. in.

This single sideband crystal filter represents one of many varieties of crystal filters now in production or under development at HUGHES.

HUGHES has the highly skilled personnel, the "know-how," and the production facilities to fill your every crystal filter need—in any quantity—and with on-time delivery!



TIGHTEN YOUR "SPECS" WITH HUGHES CRYSTAL FILTERS

Your difficult filtering problems solved with high-performance, precision crystal filters custom-designed and produced for you!

Do you face tough filtering problems in: Single Sideband, Doppler Systems, Missile Guidance, Radio Communications, Radar and Navigation, Spectrum Analyzers, Carrier and Multiplexing, Frequency Shift, High Selectivity Amplifiers?

Check these advantages of Hughes precision crystal filters: Small size, light weight, low insertion loss, low passband ripple, precise selectivity, high frequency filtering, wide temperature stability, high reliability, rugged resistance to shock/vibration, quick delivery in quantity.

Experienced Hughes Application Engineers are available to work with you on your filtering problems. For additional information on crystal filters with center frequencies of 30 kc to 52 mc, and fractional bandwidths of 0.01%-6.0%, write: HUGHES, *Industrial Systems Division, International Airport Station, Los Angeles 45, California.*

For export information, write:
Hughes International,
Culver City, California.

Creating a new world with ELECTRONICS

HUGHES

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INDUSTRIAL SYSTEMS DIVISION

See Hughes Crystal Filters on display at the Hughes exhibit, I.R.E. Show—Booths 1609-1615.

NEW AMPHENOL
"POKE R"*
CONNECTOR
features
removable
POKE-HOME®
contacts

Like the Stub R, AMPHENOL's new POKE "R" lightweight environmental connectors offer "plus" features above and beyond the minimum established by specifications. It offers you the *added advantage of removable crimp type contacts* that simplify wiring, assembly, circuit modification and reassembly if necessary.

Due to special design, Poke "R" *will also pass "Altitude Immersion"* in addition to meeting R requirements of MIL-C-5015D.

Check these other important features!

- CRIMP TYPE CONTACTS eliminate solder and electrical problems from poor solder techniques.
- OPEN INSPECTION . . . crimped contacts can be inspected before being poked home into connector.
- FASTER ASSEMBLY . . . contacts shipped separately from connector . . . permitting fast crimp wiring by hand or machine.
- EASE OF REPLACEMENT . . . removability of contacts allow re-location of circuits without replacing connector.
- HIGHER ELECTRICAL SAFETY . . . using crimp contacts eliminates the chance of solder overflow to short contacts.
- METAL TO METAL BOTTOMING provided by construction of grommet clamp reduces possibility of compression set.
- LOWER ASSEMBLY COST . . . Grommet removal is not necessary for either assembly or disassembly, reducing handling and production time.
- IMPROVED RELIABILITY of wire termination due to crimping of contact with AMPHENOL four-indent crimp.

THREE SHELL STYLES ARE AVAILABLE . . . MS3100, MS3101 AND MS3106 IN SIZES 10SL THRU 36.

Remember . . . AMPHENOL provides the best and biggest integrated line of connectors and cables in the world.

*Reg. T.M.

AMPHENOL CONNECTOR DIVISION
1830 S. 54TH AVE., CHICAGO 50, ILLINOIS
Amphenol-Borg Electronics Corporation

Membership

(*Continued from page 136A*)

Admission to Associate

Anas, V. R., Franklin Park, N. J.
Atkind, I., Trotwood, Ohio
Ault, R. D., Nashua, N. H.
Baeten, W. A., Minneapolis, Minn.
Baker, R. L., North Platte, Nebr.
Bathauer, R. N., Montebello, Calif.
Bidun, E. L., Van Nuys, Calif.
Boan, B. H., Baltimore, Md.
Burton, R. R., Kansas City, Mo.
Calderin, N. J., Cienfuegos, L. V., Cuba
Chryssopoulos, T., Thessaloniki, Greece
Cockburn, B. K., Vancouver, B. C., Canada
Conte, P. F., Winston-Salem, N. C.
Cram, R. W., Fort Huachuca, Ariz.
Csia, J. Z., Dundas, Ont., Canada
DeClark, R. S., Nutley, N. J.
Denny, R. O., Kansas City, Mo.
Diehl, G. A., Chatham, N. J.
Dobkin, R. C., Philadelphia, Pa.
Evans, E. C., London, Ohio
Evers, J. H., Harrington Park, N. J.
Fekete, J. M., Pittsburgh, Pa.
Feldman, A. W., Liverpool, N. Y.
Fischer, R. L., Pittsburgh, Pa.
Flippin, R. B., San Jose, Calif.
Fuller, H. W., Kew Gardens, L. I., N. Y.
Garfein, A., Syracuse, N. Y.
Garner, D. L., Chicago, Ill.
Geeslin, H. A., Kernersville, N. C.
Goedjen, R. W., Bensonville, Ill.
Gold, R. A., Far Rockaway, N. Y.
Grayson, C. M., Williamsport, Pa.
Gregg, L. T., El Paso, Tex.
Greenwood, S. J., North Burnaby, B. C., Canada
Gutenstein, R. G., New York, N. Y.
Hardy, T. L., Huntsville, Ala.
Hase, W. F., Jr., Louisville, Ky.
Heilbrunn, M., New York, N. Y.
Heumann, R. A., Pomona, Calif.
Hewitt, D. E., San Francisco, Calif.
Hicks, B., San Antonio, Tex.
Hitchen, H. W., Anchorage, Alaska
Hobson, W., Philadelphia, Pa.
Jansen, J., Washington, D. C.
Johnscon, E. I., Denver, Colo.
Johnson, S. L., Marblehead, Mass.
Kennedy, T. G., Boston, Mass.
Klein, L., New York, N. Y.
Knouff, S. B., Port Washington, L. I., N. Y.
Knudsen, K. L., Hareskovby, Denmark
Kosinski, F. J., New York, N. Y.
Kotani, S., Okubo, Akashi, Japan
Kurtz, Y., Kiriat Hayim, Israel
La Frentz, P. H., Inglewood, Calif.
Lagerman, A. J., Fairbanks, Alaska
Lees, G. R., Chicago, Ill.
Lien, D. A., Kansas City, Mo.
Lupton, F. A., Jr., Dayton, Ohio
MacKinnon, N. J., Toronto, Ont., Canada
Marchesini, J. C., Brooklyn, N. Y.
Maschmann, F. H., Dwight, Ont., Canada
McVicar, S. H., Jr., Danbury, Conn.
Meszaros, A. L., Hamilton, Ont., Canada
Meyers, D. V., Dayton, Ohio
Monrad-Krohn, L., Trondheim, Norway
Montz, W. F., Chicago, Ill.
Moran, J. P., Chicago, Ill.
Morrison, R. H., San Gabriel, Calif.
Munk, M. R., New York, N. Y.
Murphy, W. P., Jr., Miami, Fla.
Neville, T. E., Orlando, Fla.
O'Connor, R. E., San Jose, Calif.
Paustenbach, D. R., Revere, Mass.
Peelle, A. R., Whittier, Calif.
Perry, D. W., Silver Spring, Md.
Rahm, W. E., Jr., Princeton, N. J.
Richter, H. F., Stockholm, Sweden

Membership

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Rojenko, P., Toronto, Ont., Canada
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Sienkiewicz, J. M., Brooklyn, N. Y.
Sipes, R. G., Tucson, Ariz.
Smith, D. G., Los Angeles, Calif.
Smith, R. J., Fort Huachuca, Ariz.
Smith, S. L., Fort Wayne, Ind.
Snyder, R. L., Flushing, N. Y.
Sorkin, A., Chicago, Ill.
Stodola, R. A., La Mirada, Calif.
Stovin, W. R., Camp Valcartier, Que., Canada
Taylor, W. H., Oakville, Ont., Canada
Tennant, T. A. J., Buenos Aires, Argentina
Tilley, G. R., Indio, Calif.
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Tsang, S. F., Hong Kong, British Crown Colony
Tuma, C. F., Cleveland, Ohio
Uncapher, E., Jr., Baltimore, Md.
Vatalaro, A. V., Bayonne, N. J.
Veldhuizen, F. T., Palo Alto, Calif.
Waddell, T., Edmonton, Alberta, Canada
Waddle, C. D., Farmersville, Calif.
Warner, C. W., Smiths Falls, Ont., Canada
Waters, M. F., Utica, N. Y.
White, M. B., St. Petersburg, Fla.
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FOR HIGH RELIABILITY IN

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APPLICATION

Featuring EXTREME DEPENDABILITY UNDER CONDITIONS OF:

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- HI-ALTITUDE • HI-HUMIDITY

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MODEL 82 TRANSISTORIZED MISSILE IF AMPLIFIER features the ruggedness and proven performance of the LEL IF64 missile amplifier at 1/50th the power requirement. The standard model 82 has a 10 mc bandwidth at 60 mc center frequency. Amplifiers embodying the features of the 82, but with electrical characteristics to meet your system requirements, can be supplied.

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COPIAGUE, L.I., N.Y.

DC-8
UNITED
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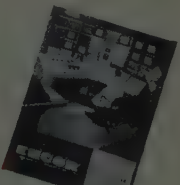
JETS GET THEIR FLIGHT PLAN DATA PROCESSED BY COMPUTOR HOUSED IN

EMCOR® CABINETS

An EMCOR cabinet houses an electronic computer designed to furnish flight plan data for DC-8 Jet Mainliners, United Air Lines, Chicago, Illinois. The computer stores in its memory the operating and performance characteristics of the DC-8 aircraft, including such things as fuel flow, air speed, rate of climb, routes, altitude restrictions, compass headings, distance between check points, etc.

EMCOR design "know-how" in producing standard cabinets featuring the most modern concept in metal cabinetry is keeping pace with the new age in air travel. The flexibility, versatility and structural capabilities of over 600 basic frames in the EMCOR MODULAR ENCLOSURE SYSTEM bring advanced engineering and "imagineering" to meet electronic and instrument packaging requirements.



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QUALITY EMCOR PRODUCTS®

Originators of the Modular Enclosure System

ELGIN METALFORMERS CORP.
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VISIT US AT BOOTH 4420-4424 DURING IRE SHOW, NEW YORK COLISEUM

Whom and What to See at the Radio Engineering Show

March 21-24, 1960 **New York Coliseum**

These pages list the exhibitors at the Radio Engineering Show, with a brief description of what each exhibitor is showing, and a list of company personnel manning the booth. In each listing the booth number is given. Almost all booths have a 4-digit number. The first digit indicates the floor, the second digit indicates the aisle (aisle numbers increase from south to north). A few booths have one or two digit numbers, preceded by the letter "M". These booths are on the mezzanine at the back of the first floor. The show is divided into sections of related products, to help you in finding the products of your primary interest as easily as possible. These sections are:

First and Second floors—Components.

Third floor—Instruments and Complete Equipment. Communications Equipment and Systems, Computers, and instruments for test and measurements, microwave equipment.

Fourth floor—Production. Machinery, tools, and raw materials; fabricators and services.

ACF Industries Incorporated
ACF Electronics Division
Riverdale, Md. & Paramus, N.J.
Booth 1113

John H. Fournier, George B. Shaw, Robert Young, John A. Curtis, W. H. White, M. M. Millette

Industrial Components, Microwave Components. The Avion Division and the Nuclear Products-Erco Division of ACF Industries Incorporated have been consolidated into the new ACF Electronics Division. Headquarters of the new division is in Riverdale, Maryland, with plants in Riverdale and Paramus, New Jersey; sales office in Culver City, California; and the Electro-Physics Laboratory in Bladensburg, Maryland.

A'G'A Division, Elastic Stop Nut Corp. of America, Booth 2343
1027 Newark Ave.
Elizabeth 3, N.J.

H. Bostrom, S. Knapp, J. Newman, J. A. Long

Agastat Time Delay Relay. Qualified to military specifications and aircraft requirements. Agastat miniature relay unaffected by voltage variation, instantaneously recycling; time settings from .030 sec. to 120 seconds. Hermetically sealed or dust tight housings AC or DC contacts carry inductive load of 2 amps at 30 volts dc and 3 amps at 100 volts ac.

AMP Incorporated, Booths 2529-2531
Eisenhower Blvd.
Harrisburg, Pa.

B. Connel, A. Curtis, W. Haas, D. Hajjar, T. Harris, W. Hildebrand, O. Holmes, F. Howell, T. Kerr, J. Lyter, J. Miller, J. Pierce, J. Rausch, J. Simpson, E. Spooner, C. Stoup, J. Taylor, H. Wasiele

Patchcord Programming Systems—universal and shielded systems and accessories. Pin. Boards—for matrix programming. Double Throw Instrumentation Switches—(80-1500 pole). Multiple Aperture Devices (MAD)—features digital and analog memory planes. Maintainable Electronic Component Assemblies (AMP-MECA)—New modular assembly technique. AMPin-cert—Line of rack and panel connectors incorporating solderless pins and sockets. TERMASHIELD—Line of splices and ferrules designed for critical applications employing any shielded wire.

AMP Incorporated, Capitron Division, Booth 2527
155 Park St.
Elizabethtown, Pa.

W. Haas, G. Latch, J. O'Brien, E. Polk, J. Thomas, R. Tingleff, W. Weber

High Voltage Capacitors; Quadrupler—circuit arrangement of rectifiers and capacitors that allow an approximate set-up of voltage from transformer to output of 4 to 1; Delay Lines—lumped constant and distributed constant types featuring fast rise times and low attenuation.

PLAN IN ADVANCE!

Use this issue of *Proceedings of the IRE* to make your plans well before you get to the convention and show. Decide which technical sessions and social events you want to attend, and what exhibits at the show you will find of most interest. Advance planning will save you a great deal of time and effort, and will insure that you do not miss seeing or hearing about that one new product or technique which may be of vital importance to you in your work during the next year.

A.P.M. Corporation
252 Hawthorne Ave.
Yonkers 5, N.Y.
Booth 1229

▲ Riva Solins, ▲ Milton Morse, E. Otto Kennedy, Nat Kronstadt, Murray Sparks, Joan Misley

New NUP121M Power Connector

New *NUP121M Power Connectors with automatic, self-grounding feature will provide ground connection when plugged into either 2 or 3 pole receptacles without need for special adaptor. Switch and shaft seals, self-sealing fasteners. All products meet military specifications.

A.R.F. Products, Inc., Booth 3938
7627 W. Lake St.
River Forest, Ill.

▲ Arthur H. Maciszewski, ▲ John J. Pakan, M. Z. Massel, A. Przedpelski, J. Skolnick, D. J. Hamilton, Eugene D. Cahn

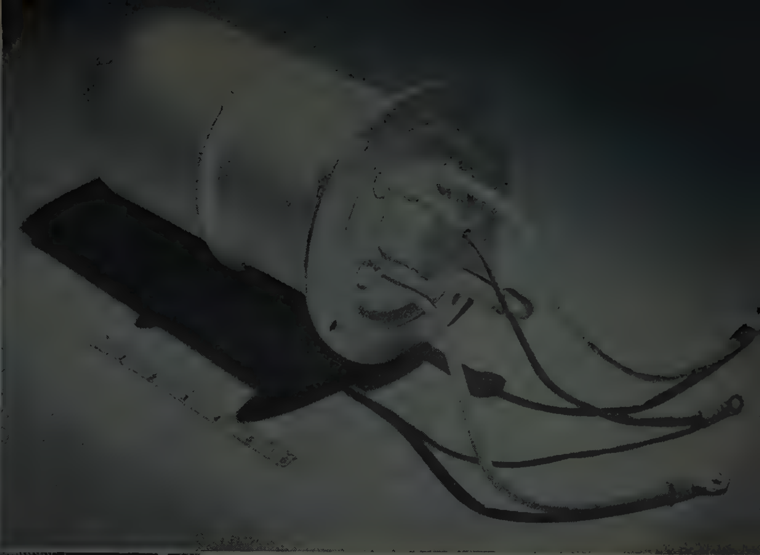
Research and Manufacturing facilities: AR-1B and AR-2 Deviation Meters, AN/UPM-15 Pulse Generator, pulse type transmitter and receiver for remote control, ARN-18 Glide Slope Receiver, ART-1 Miss-distance Indicator Transponder, AR-4 Miss-distance Indicator Ground Station, Precision Printed Circuits.

(*Continued on page 142A*)

▲ Indicates IRE member.

* Indicates new product.

Manson Laboratories, Stamford, Connecticut, designed six GL-7390's into this modulator whose power capability is 78 megawatts peak and 300 kilowatts average.



Below are shown the approximate envelope sizes and power outputs of two thyratrons now in use in high-power radar, as compared to the new General Electric tube.

Type 1257	Type 5948	New G-E Development (GL-7390)
8½"x20"	5"x16"	6"x11"
Avg. Power 33KW Peak Power 33MW	Avg. Power 12.5KW Peak Power 12.5MW	Avg. Power 66KW Peak Power 33MW

CHARACTERISTICS:

Peak Anode Voltage	33 KV
Average Anode Current	4 amperes
Peak Anode Current	2,000 amperes
Anode Dissipation Factor	30×10^9

Advanced General Electric Hydrogen Thyratron Available NOW from Stock!

The new General Electric GL-7390 hydrogen thyratron, which has the highest known power handling capability of any hydrogen thyratron now available, can be shipped immediately from stock. Designed for high-power radar pulse modulators, the GL-7390 features metal-ceramic construction for great mechanical ruggedness, smaller size for important space savings, and ability to switch extremely high average and peak power.

The external anode and grid construction allows direct convection cooling of the anode and grid. Reduced anode and grid temperatures during operation minimize the possibility of arc-back and/or grid emission.

Ceramic-metal construction provides a rugged envelope which enables the GL-7390 to withstand shock and vibration conditions beyond the limits of glass designs. The anode and grid are in the form of solid metal cups solidly brazed to the ceramic body. This is a far stronger design than conventional glass seals and lead supports.

The metal-ceramic construction allows close, accurate, and rigidly fixed spacings of the anode and grid. The result is very reliable high-voltage operation. Application assistance available from your regional General Electric power tube office. *Power Tube Department, General Electric Company, Schenectady 5, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Problem:
to secure an
Absolutely Reliable Connector
FREQUENCY RANGE 5 KMC—11 KMC
VSWR 1.25:1 maximum

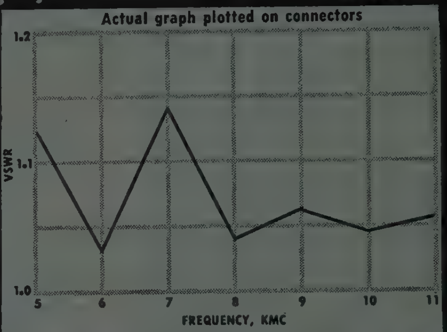
Solution:
Individually
*CALIBRATED
CONNECTORS
for
Missile and Precision Equipment

KA-11-06
KA-51-05

KA-11-06 and KA-51-05 Connectors, part of KINGS' TNC group, are the newest examples of KINGS quality and reliability found in its complete line of Coaxial Connectors and R. F. Components manufactured to conform to government specifications. Write for full information.

Our Engineering Department is available for assistance on your connector and R. F. component problems.

* at 100 mc intervals



KINGS Electronics CO., INC.
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See us at Booths 2821-2823 IRE Show

BEEMER ENGINEERING COMPANY
"precision products for Industry"

OILITE
METAL POWDER
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AERO DUCT
FLEXIBLE DUCTING
& COUPLINGS

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O-RINGS - ALL GRADES
SILICONE PRODUCTS

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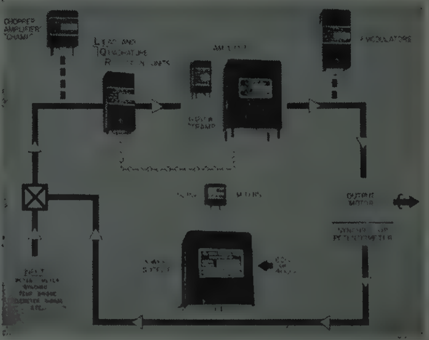
At the 1960 IRE Show
See the
"SERVO BUILDING
BLOCKS"
SELECT standard components
to assemble any servo loop
- Power Supplies
- Lead and Quadrature Rejection Units
- Surge Limiters
- Transistor Amplifiers

Also see:
- Rotor Balancers
- Integrators
- Computers



M. TEN BOSCH, INC.
80 WHEELER AVENUE • PLEASANTVILLE, N. Y.

Whom and What to See at the Radio Engineering Show

(Continued from page 140A)

ARRA
Antenna & Radome
Research Associates
1 Bond St.
Westbury, L.I., N.Y.
Booth M-9

▲ Norman Spector, ▲ Harold B. Isaacson, Howard A. Feiner

Continuously Variable Attenuator

Continuously variable coaxial attenuators, continuously variable flat coaxial attenuators, flat fixed attenuators, flat directional couplers, terminations, tuners and power dividers, in coax. Waveguide accessories include rigid transmission lines, bends, tees, twists, and hybrids.

Ace Electronics Associates, Inc.
99 Dover St.
Somerville 44, Mass.
Booths 1811-1813

▲ Aaron N. Solomon, ▲ George Berman, ▲ John Mastromarino, ▲ Lou Berni, ▲ Bill Lyons, ▲ Ezra Sheffres

Manufacturers of precision wirewound and conductive plastic potentiometers and trimmers, in a full range of resistances, sizes from ⅜" to 3". Linear and nonlinear. Bushing and servo mountings, rotary and rectilinear. All designed to MIL specs. Specials, prototypes and production.

Ace Engineering & Machine Co., Inc., Booths 3928-3930
Tomlinson Road
Huntingdon Valley, Pa.

Frances M. Fay, ▲ Charles C. Borden, ▲ Edwin S. Kesney, ▲ Harry W. Kenny, Samuel Mitchell, C. R. Schaller

Shielded enclosure cut-away construction details. Basic designs are Ace Cell Type, RFI Solid Sheet Metal, Laminated Core Type. *Newest design features thermally insulated r-f enclosure. Tested and approved from 14 kc through 10 kmc. Design & Test Engineering services available.

(Continued on page 144A)

▲ Indicates IRE member.
* Indicates new product.

First Aid Room

A nurse is in charge at all times. First aid room is located on the first floor mezzanine, northwest corner of the first floor. Take elevator 20.

LITTLE INSTRUMENTS BY DeJUR PERFORM BIG PRECISION FUNCTIONS

Potentiometers

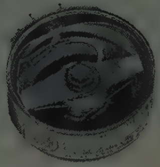
Small but Accurate—unique design and production techniques assure exceptional functional accuracy.

SERIES C-050

½". Sealed, sub-miniature type with one-piece metal case and bearing. Completely enclosed. Solid terminals, integrally cored with molded covers. Rotation: 320° electrical, 325° mechanical, 360° continuous.

SERIES C-078

⅞". Weight only ½ ounce. Independent linearity: ±1% of total resistance is standard. Linear or non-linear windings on flat card. Fully enclosed. Tolerance: ±5% standard, ±1% on order.



SERIES C-178

1⅞". Sine-cosine units with peak-to-peak accuracies to 0.25%. Independent brush contacts on common shaft, 90° apart. Ganged types available. Also 2" and 3" diameters.

Panel Instruments

Ruggedized . . . round or square—miniature high precision units meet reduced size and weight requirements of aircraft and electronic applications

SERIES 100

1". Accuracy ±3% at full scale. Non-magnetic calibration. Scale length, 0.738". Background markings black or white, lance pointer, sealed solder lug terminals, aluminum housing. Watertight to meet MIL-M-3823 specs.

SERIES SC-031

½". Rugged, micro-miniature sealed unit. Includes external pivot D'Arsonval movement and high flux density Alnico magnet. Optional mounting, face plate and hex nut.

SERIES 131

1½". Ruggedized to withstand shock, vibration or thermal extremes. Meets MIL-M-10304 specs. Positive watertight seal of meter and terminal studs.

Write for detailed literature on complete lines.

You're always sure with

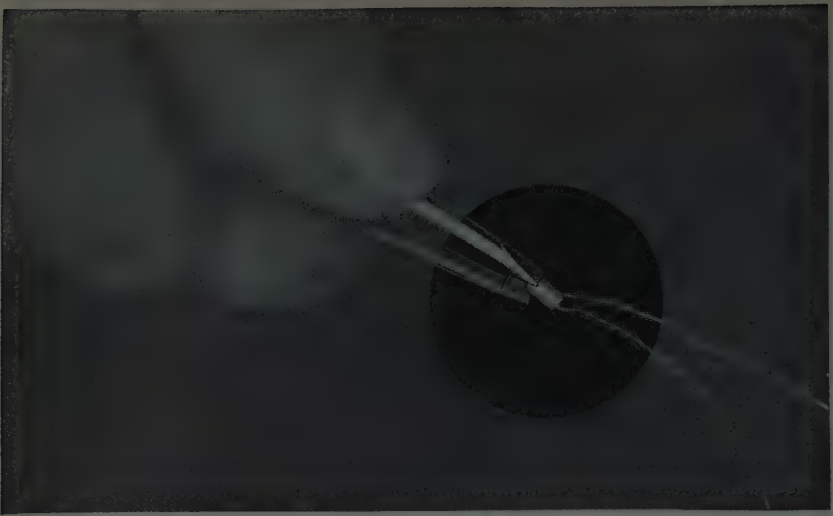
DeJUR

ELECTRONIC COMPONENTS

Manufacturers of Precision Electronic Components for Over 35 Years

ELECTRONICS DIVISION, DeJUR-AMSCO CORPORATION, 45-01 NORTHERN BOULEVARD, LONG ISLAND CITY, N. Y.

SEE US AT THE IRE SHOW BOOTHS 2307-2309



NOW – 48-56 Gauge Wire Coils built to YOUR specifications

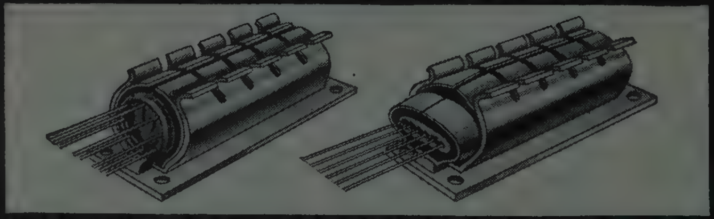
Whatever your application—from hearing aids to missile systems—Deluxe Coils' new fine wire plant can supply the miniature coils you need . . . built to your specifications for precision and accuracy.

Deluxe Coils' newest facility spans 15,000 sq. ft. It is air and sound conditioned and completely equipped to produce all types of miniature fine wire coils, 40-47 gauge, ultra fine wire coils, 48-56 gauge, and components.

Write for information on Deluxe Coils' fine wire production capabilities—and how they can be put to work for you, right away.

DELUXE COILS, INC.
POST OFFICE BOX 318 • WABASH, INDIANA

AUGAT'S REVOLUTIONARY
ELASTACLAMP*
The answer to more effective cooling of subminiature tubes!



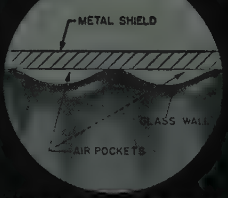
Heat-dissipating subminiature tube shield with elastic thermal conductor

SILVER SKIN
GLASS WALL
HEAT CONDUCTING ELASTOMER

Enlarged section of Elastaclamp's inner cartridge.

Resilient elastomer will completely conform to pronounced irregularities of glass surface thus reducing dangerous hot spots.

Tubes protected from severe shock and vibration by rubber-like elastomer which cushions glass.



Enlarged section conventional heat-dissipating tube shield.

For additional information write for bulletin No. 559.

AUGAT BROS., INC.
31 Perry Avenue • Attleboro, Mass.

*Trademark

Whom and What to See at the Radio Engineering Show

(Continued from page 142A)

Acoustica Associates, Inc., Booth 4120
Fairchild Court
Plainview, N.Y.

Kurt F. Vogt, ▲ Stanley Jacke, Maurice Howell, Al Paley, Wm. Katsara, Artie Liers, ▲ Robert L. Rod, Robert E. Rolnick, Samuel Markel, Wm. Abourezk, Jeanne A. LaTourette, Anita L. Langhauser

Heavy-duty ultrasonic cleaners, general purpose ultrasonic cleaners, immersible transducers, *ultrasonic cleaner accessories (baskets, pump and filter systems, covers, etc.), *ultrasonic cleaning chemicals, liquid level switches, continuous liquid level switches, and ultrasonic R & D programs.

Actioncraft Products
2 Yennicock Ave.
Port Washington, L.I., N.Y.
Booth 4041

J. F. Murphy, J. M. Pelikan, H. Emory, W. J. Murphy, B. Oglethorpe

Insulation Sleeving to meet MIL-I-631, MIL-I-7444B, MIL-I-3190. Laminated split sleeve wire markers. Insulation sleeving, silicone rubber sleeving, marked and cut to specifications. (AIRTEX) Specification electronic lacing cords.

Acton Laboratories, Inc., Booths 3840-3842
533 Main St.
Acton, Mass.

Leroy C. Bower, Jr., John Forrest, Lawrence Beloungie

Ultra low-frequency phase meters*, citizen Band Transceivers*, FM Monitors*, #453 Transmission and Delay Measuring Sets*, Precision Shaft Couplings*, Adjustable Slip Clutches*, Miniature Gear Drives*, Compact Transistorized Phase Meters, Phase Standards, Impedance Meters, Precision Drives, and Amplifiers will be displayed.

Advanced Vacuum Products, Booths 1310-1316

See: Indiana General Corp.

Ad-Yu Electronics Lab., Inc.
247 Terhune Ave.
Passaic, N.J.
Booth 3705

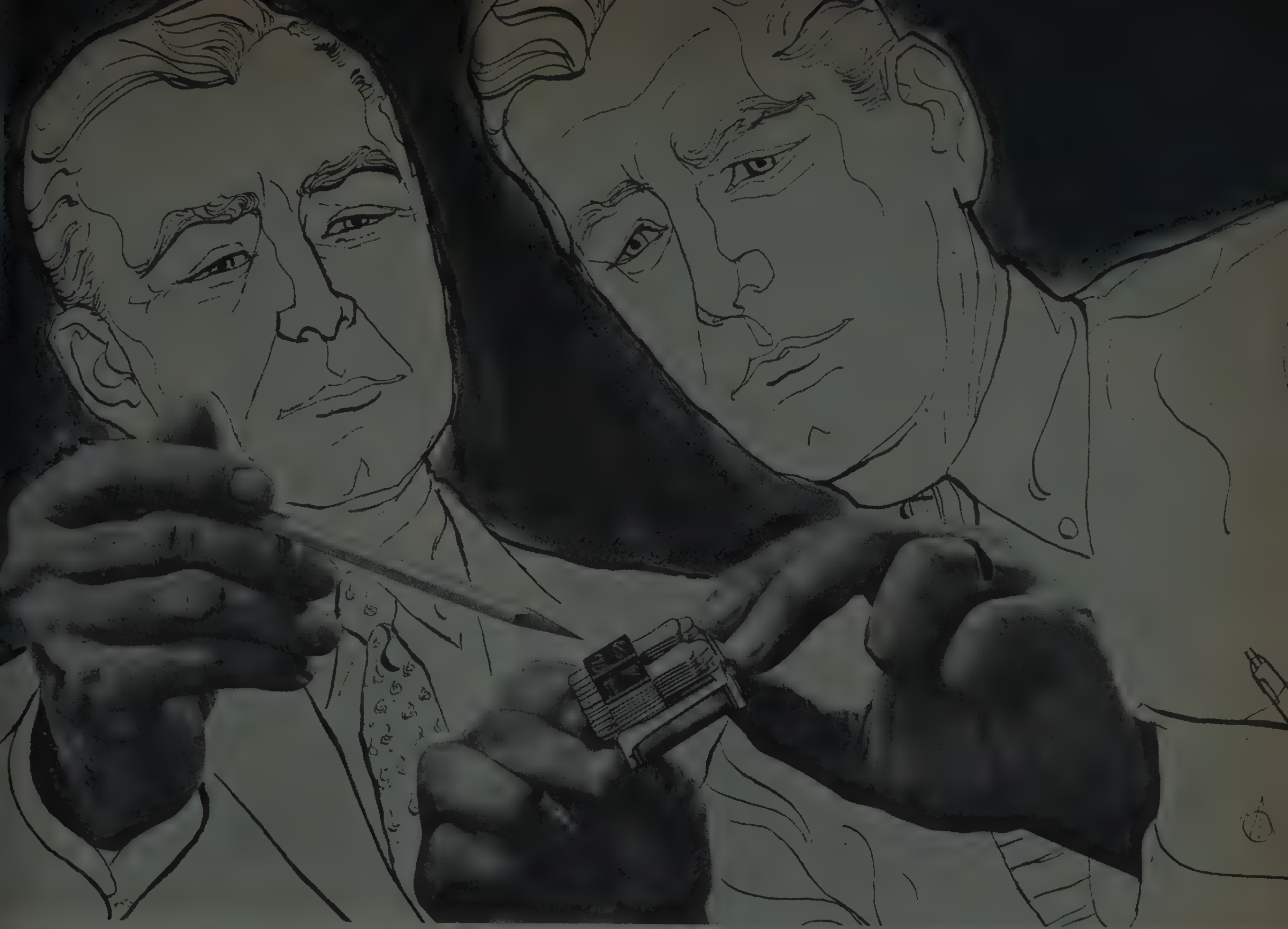
▲ Paul Yu, ▲ Annibale Lupi, ▲ Roland St. Louis, Oscar Santos

Type 205B1 Phase Detector

*Precision Millimicrosecond Phase Detectors, 15 mc to over 1000 mc; *RF Phase and Ratio Meters; direct reading Phase Meters, 1 cps to 500 kc; sensitive Phase Meter, 1° full scale, 0.005° accuracy; Phase Shifters; Delay Lines: continuously variable, step variable, tapped; Relays, 40 Microwatt sensitivity, meet MIL specifications.

(Continued on page 146A)

▲ Indicates IRE member.
* Indicates new product.



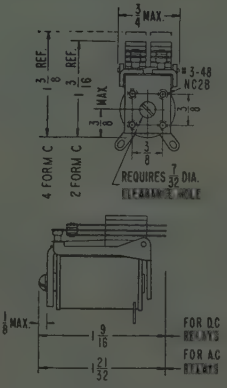
COMPACT, RELIABLE, VERSATILE . . . this is P&B's miniature MH relay

The MH is not a new relay.

As a matter of fact, we've been building and selling this series for seven or eight years. Its reliability and exceptional longevity have been proved in business machines, airborne computers and a host of other products.

Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms . . . up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.



MH ENGINEERING DATA

GENERAL:

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: −45° C to +85° C. (−65° C to +125° C on special order.)

Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps.; .065″ max. excursions from 10 to 55 cps. on special order.

Weight: 2½ ozs. max. (open relay)

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛″ silver standard: Palladium or gold alloy also available.

Load: Dry circuits to 5 amps @ 115V AC res.

COILS:

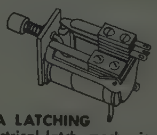
Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25° C max. (200 mw min. to meet max. shock/vibration spec.)

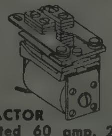
Duty: DC: Continuous. AC: Intermittent (Two pole relay max.) open. Sealed units supplied with full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

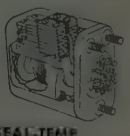
The relays below are variations of the MH relay structure.



MA LATCHING
Electrical latch, mechanical reset. Small, versatile and offered with selection of contact arrangements.



MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

all types of KNOBS

AVAILABLE FROM
STOCK MOLDS
OR CUSTOM MOLDED
TO YOUR OWN DESIGN

Shown above are just a few of the many Rogan knobs available from stock molds. No tool charge. Fast delivery. Markings can be branded to fit your requirements. Special shaft holes at nominal cost. Send for details and free catalog.

Visit Booth 1048 at the IRE Show

ROGAN BROTHERS

8009 N. Monticello • Skokie, Illinois

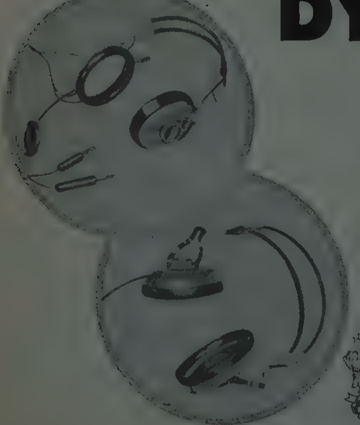
AMERICA'S FOREMOST MOLDERS AND BRANDERS OF PLASTIC KNOBS

LOW LEVEL DC AMPLIFIER

Model 759-6* low level DC amplifier accepts DC signals from 5μv to 1 volt. It will indicate on its own panel-meter or record on a meter-type recorder. Having an inherent accuracy of 0.25% and a stability of 5μv, the instrument features low noise and is low in cost. See it at booth 3017, IRE Show. *Also, model 759-5, without panel meter.

MAGNETIC INSTRUMENTS CO., INC. THORNWOOD, N.Y.

A Subsidiary of Pyrometer Company of America, Inc.



DYNA-TWIN®

by TELEX

available with or without Boom-Mike

The Dyna-Twin, a new headset of superior quality and performance, superior noise abatement characteristics. Excellent fidelity. Being lightweight and designed for maximum comfort it is ideal for all binaural and monaural applications. Dyna-Twin is engineered to withstand the rigorous environmental problems of temperature, humidity, vibration and shock. Choice of 4 mikes.

SEE IT IN BOOTH 2919 — IRE SHOW

TELEX, INC.

Electro Mechanical - Acoustic Division
Telex Park • St. Paul 1, Minnesota

Whom and What to See at the Radio Engineering Show

(Continued from page 144A)

Aeroprojects, Inc.
310 E. Rosedale Ave.
West Chester, Pa.
Booth 4238

W. C. Potthoff, D. D. Kirkpatrick, E. B. Webb, W. N. Rosenberg, E. D. Haigler, ▲ C. DePrisco, B. A. Valocchi

Ultrasonic Metal Joining Equipment. Featuring a new *600 Watt Sonoweld Unit for joining a variety of similar & dissimilar metals.

Aerovox Corporation, Booths 2603-2607
740 Belleville Ave.
New Bedford, Mass.

Frank Marshall, Charles E. Krampf, Cyrus Stonehill, James Krampf, Ralph Parker, ▲ Louis Kahn, ▲ Dr. Antonio Rodriguez, Arthur Warner, ▲ Harvey Pickett, Ruppert Jarboe, Roy Roskilly, Abraham Kalstein, Per Bogh Henrikssen, Thomas Cary, Owen Wood, G. Robert Tinay, Paul Goley, Guy Gardner, Charles Snow, Henry Taylor

CEROL—Rolled ceramic capacitors with high reliability and high capacitance. CERAFIL—ultra miniature ceramic capacitors . . . High Quality, Long-Life electrolytic capacitors; Epoxy clad Plate Assemblies; Aeroglaze carbon-deposited resistors; POLYCAP capacitors in paper and electrolytic types.

Aetna Electronics Corp.
Readington Road
North Branch, N.J.
Booth M-1

▲ Joseph F. McDonald, John Perkins, Frank Hunter, Robert McDonald, Henry Buser, Robert Wentworth

Servo Analyzer

Servo Analyzers .0008 to 100 CPS, Transmitter Inductors & Capacitors, Ultrasonic Generator Tuning Inductors, Magnetostriction Transducers.

Ainslie Corp.
531 Pond St.
South Braintree 85, Mass.
Booth 1221

Lawrence D. Ainslie, ▲ H. W. Ainslie, S. Hassan, D. J. Cantelli

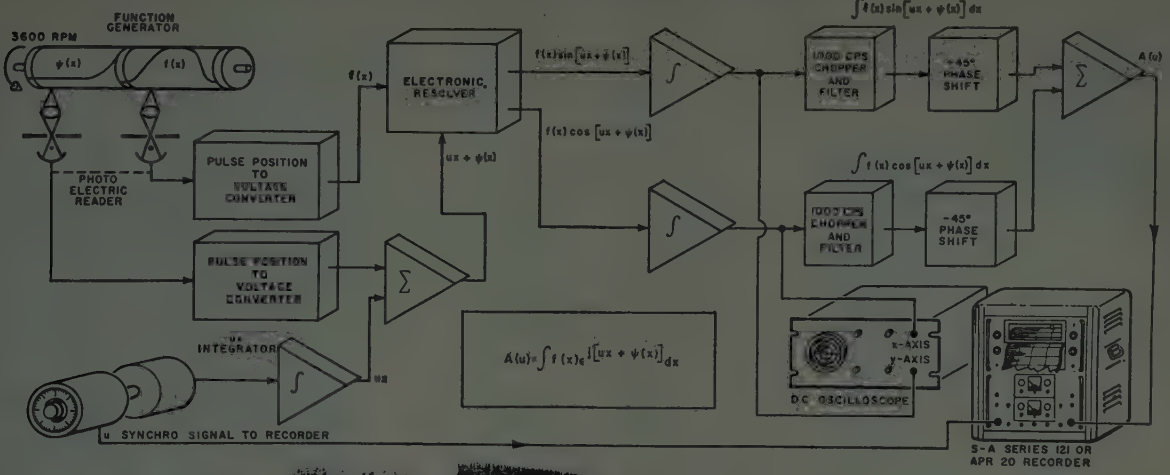
Designers and Manufacturers of Microwave Antennas and Associated Equipment. Reflectors. Precision fabrications for the electronic industry.

(Continued on page 148A)

▲ Indicates IRE member.
* Indicates new product.

Be sure to
see all four floors!

Simplified block diagram of Model CF-1. Amplitude and phase input functions are plotted on graph paper for presentation. Integration is observed on a dc oscilloscope. Absolute magnitude is recorded on any S-A Series 121 or APR 20 Antenna Pattern Recorder with a logarithmic response.


FUNCTION GENERATOR
3600 RPM
ψ(x)
f(x)
PHOTO ELECTRIC READER
PULSE POSITION TO VOLTAGE CONVERTER
PULSE POSITION TO VOLTAGE CONVERTER
f(x)
ELECTRONIC RESOLVER
ux + ψ(x)
ux INTEGRATOR
ux
u SYNCHRO SIGNAL TO RECORDER
f(x) sin [ux + ψ(x)]
f(x) cos [ux + ψ(x)]
∫ f(x) sin [ux + ψ(x)] dx
∫ f(x) cos [ux + ψ(x)] dx
1000 CPS CHOPPER AND FILTER
1000 CPS CHOPPER AND FILTER
+45° PHASE SHIFT
-45° PHASE SHIFT
A(u)
A(u) = ∫ f(x) ε^j[ux + ψ(x)] dx
x-AXIS
y-AXIS
DC OSCILLOSCOPE
S-A SERIES 121 OR APR 20 RECORDER

To solve

$$A(u)=\int_{-1}^{1} f(x)\,\epsilon^{j[ux+\psi(x)]}\,dx$$

investigate the new

FOURIER INTEGRAL COMPUTER

Model CF-1

A sophisticated solution to the vexing problem of solving bounded Fourier integrals quickly and accurately, Scientific-Atlanta designed the Model CF-1 especially for the antenna design engineer.

The computer has broad general application including determination of the far fields of aperture antennas from the distribution of the field in the aperture, the far fields of arrays from the magnitude and phase of the currents in the elements, the frequency spectra of voltage pulses, and other physical problems involving Fourier transforms and their inverse transforms over finite limits.

PRICES

Model CF-1 Fourier Integral Computer . . . $9,000

Model APR 22 Antenna Pattern Recorder (logarithmic response) . . . $4,300

See the CF-1 and other new S-A Microwave Instrumentation at IRE Booth 3909

Consult your nearby S-A engineering representative for more information. Or you may write directly to the factory for complete specifications. Address Dept. 433.

SCIENTIFIC-ATLANTA, INC.
2162 PIEDMONT ROAD, N.E. • ATLANTA 9, GEORGIA
Tel. TRinity 5-7291

4

superb new
NULL
DETECTOR

KEITHLEY INSTRUMENTS
151 NULL DETECTOR
ZERO
ZERO
POWER
INPUT

The new Keithley 151, incorporating a unique photo-conductive modulator of Keithley design, is useful wherever a suspension galvanometer can be used, and where a galvanometer is not sufficiently sensitive, fast or rugged. Currents as low as 2 x 10^{-13} ampere can be detected.

Ranges: 11 linear ranges in 1x and 3x steps, from 100 μv to 10 v f.s.; 5 non-linear ranges, 0.001 to 10 v f.s., each covering three decades.

Accuracy: Linear ranges, ±3% of f.s.; non-linear, ±10% of input.

Input Resistance: 10 megohms on all ranges. Max. power sensitivity over 10^{-17} watt.

Response Speed: On 100 μv range, 2.5-sec.; 1-sec. on all others.

Noise: Below 2% f.s. all ranges.

Zero Drift: Less than 10 μv per day.

Output: 10 volts at 1 ma f.s.

Price: 151 Cabinet Model . $395.00
151R Rack Model . $385.00

Booth 3907, IRE Show

KEITHLEY
INSTRUMENTS

12415 EUCLID AVENUE
CLEVELAND 6, OHIO

Whom and What to See at the Radio Engineering Show

(Continued from page 146A)

Airborne Instruments Lab.

Division of Cutler-Hammer, Inc.
Deer Park, L.I., N.Y.
Booths 3316-3318, 3413-3417

▲ J. Bisby, G. McCarthy, ▲ A. Robertson, M. Rowe, J. Cunningham, W. Woodbury, D. Clark, ▲ H. Hechtman, ▲ M. Lebenbaum, ▲ C. Fowler, ▲ W. Tolles, ▲ G. Litchford

Systems & Equipment in the Fields of Radar, Radio Astronomy, Microwave, Medical Electronics, Receivers and Amplifiers, Automation, Space Technology, Air Traffic Control Antennas & Computers.

Aircom, Inc.

48 Cummington St.
Boston 15, Mass.
Booth 1106

▲ Robert A. Rivers, Edward J. Stack, Herbert Shprentz

AIRCOM
INCORPORATED
48 CUMMINGTON ST., BOSTON, MASS.

*Telemetering Antennas, *Beacon Antennas, *Telemetering-Transmitters, *3 DB Sidewall Coupler, *Matched Hybrid, *Noise Sources, *Cast Short Cavities, Microwave Equipment; Tees, Couplers, Detectors, Attenuators, Loads, Tuners, Slotted Lines, Gain Standard Horns, Phase Shifters, *Adapters.

Airflyte Electronics Co., Booth 1217
535 Avenue A
Bayonne, N.J.

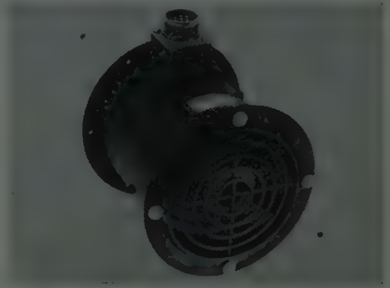
Milton Feinman, Robert Schmitt, Thomas Monaco, Raymond Ferri, Richard O'Brien, Ben Novy

Slip ring assemblies and brush block assemblies for synchros, resolvers, gyros, strain gages, radar pedestals; commutating devices for sampling, analog digital conversion, telemetering, and all switching applications. All items per MIL-5272, MIL-E-5400, and MIL-E-5422.

Air-Marine Motors, Inc.

369 Bayview Ave.
Amityville, L.I., N.Y.
Booth 2601

▲ Arthur W. Forsberg, ▲ Oskar W. Giesecke, William L. Sly, James E. Foltz, ▲ David H. Thomas



Vane Axial Blower, Model E-2543-200

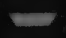
Due to unique design and Class F insulation, the E-2543-200 blower withstands an ambient of 85°C and has life above 5,000 hours. Meets MIL-E-5400B and MIL-E-5422D. Weighs only 3½ lbs, delivers 200 CFM at ¾″wg, operating from a 200V, 3Ø, 400 cps supply.

(Continued on page 152A)

FOREMOST
IN DELAY LINES

NEW

Lumped-constant delay lines with 100-1 delay to-rise time ratios, low attenuation, minimum volume . . . , now on a regular production basis.

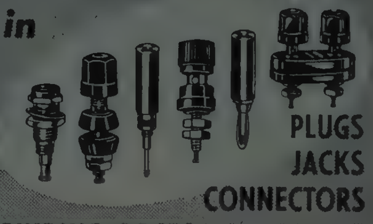


For literature on our many types of delay lines, write

COLUMBIA TECHNICAL CORP.
61-02 31st AVE., WOODSIDE 77, N. Y.

See us at booth 1112 IRE Show

SMITH Makes
EVERYTHING
in



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Industrial users of electronic components know that "It's Sound Planning to Specify SMITH" because:

- SMITH quality of materials and workmanship cannot be surpassed.
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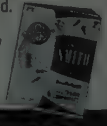
- SMITH standard products can be found on the shelves of every important distributor from coast to coast.

We have facilities for speedy and economical production of special parts and assemblies to rigid specifications. Inquiries invited.

SPECIFY SMITH

Send for your copy of our 44-page Catalog No. 59

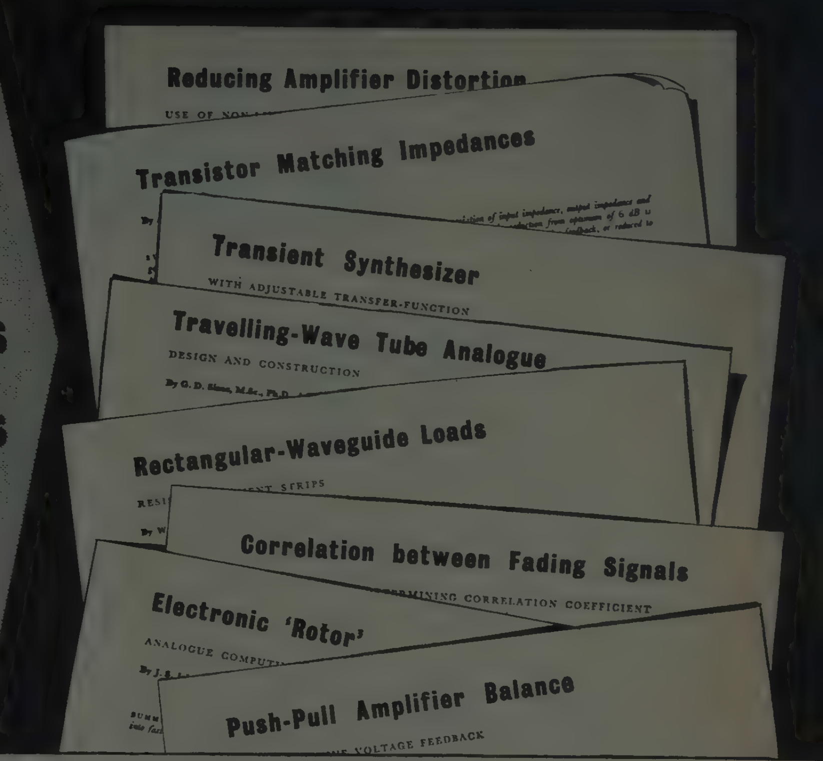


HERMAN H. SMITH, INC.
Manufacturers of Electronic Components
2326 NOSTRAND AVENUE • B'KLYN 10, N. Y.
CLOVERDALE 3-7900

See Us At IRE Show Booth #2325

n essential source
f information for
esigners, technicians
nd research workers
n electronics

ILLUSTRATED ARE SUBJECT HEADINGS
FROM THE JANUARY 1960 ISSUE


Reducing Amplifier Distortion
Transistor Matching Impedances
Transient Synthesizer
WITH ADJUSTABLE TRANSFER-FUNCTION
Travelling-Wave Tube Analogue
DESIGN AND CONSTRUCTION
Rectangular-Waveguide Loads
Correlation between Fading Signals
Electronic 'Rotor'
Push-Pull Amplifier Balance

Electronic Technology—in step with the accelerated expansion and diversification of electronics—embraces the subject with new thoroughness.

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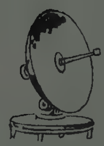
ADDRESS...
.... CITY.......................
ZONE .... STATE ....

at Melpar...

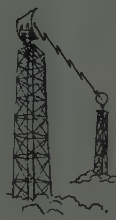
MELPAR APPLIES ELECTRONIC CREATIVITY TO SEVEN PRINCIPAL AREAS OF ACTIVITY

DETECTION & IDENTIFICATION —Melpar has exceptionally broad experience in data analysis. Melpar designs and develops special equipments and systems for early detection and identification. A large engineering capability has been assembled in these areas. New detection-identification methods and techniques are constantly being developed.



ANTENNAS AND RADIATION— Equipped with the best research and development facilities, Melpar is able to reduce customers' requirements to physical equipments. Melpar, supporting its leadership in advanced concepts, has established 19 antenna test ranges for proof of performance. Also, Melpar provides a unique quick reaction facility through its "follow on" production. The Company's experience in new ordnance and electronic countermeasures systems is currently being applied to the nation's newer missile and satellite programs.

FLIGHT SIMULATION & TRAINING —Concurrent design and development of simulation and training equipment that matches the exacting demands of new aircraft schedules gives Melpar proved ability to design and develop complete mission-type simulators for fixed and rotary-wing aircraft, radar and fire control, and missiles. Melpar excels in the ability to derive and reproduce system analogs rapidly while accurately preserving all of the original equipment's tolerances.



COMMUNICATION & NAVIGATI —Leading in the application of n printed circuit techniques to ach a new order of miniaturization compact design, Melpar is respons for many innovations and new cepts in data transmission links, mi wave receivers, communication term equipment, secure communications vices, and remote control systems. par maintains extensive field operati including a facility at Tucson, Ariz where avionic equipment and syst are studied, installed, and tested the Army's Electronic Proving Gro (Fort Huachuca).

PHYSICAL SCIENCES—Recogni the need for a partnership betw electronics and physical sciences, par has established a materials resea laboratory within its electronics c plex. Research on the structure application of new materials to sup electronics is advancing at Mel Experienced research staffs are evolving practicable, workable des in such areas as high temperature ef on materials and molecular electro

...proved ability, experience assure electronic achievement

MELPAR'S ENGINEERING DIVISION makes a continuing creative contribution to electronic development. And a number of significant electronic achievements have resulted from Melpar's imaginative approach to project and system engineering.

Electronic achievement at Melpar resulted in the conception, design, and production of one of the largest airborne electronic systems ever developed—the first integrated electromagnetic reconnaissance system . . . and two of the largest ground electronic systems—a ground based reconnaissance data handling system, and the F-101B weapon system simulator.

MELPAR EQUIPMENTS form an integral part of many advanced weapons systems, and equipment developed at Melpar will comprise a part of the first manned-satellite launched into orbital flight.

DATA HANDLING—Melpar designs, develops, and produces fully automatic data handling systems with both tremendous data gathering capacity and the ability to process results in a relatively short time. New approach philosophies have been applied to the development of special purpose computers, tactical displays for weapons systems, and systems for both data reduction and data processing. Melpar has full data handling resources, with a broad range of customer services—from problem analysis to complete system design.

RECONNAISSANCE—Early design and development experience with reconnaissance systems led Melpar to recognition of the possibilities inherent in new reconnaissance techniques. Now, Melpar leads the industry in the development, design, and production of reconnaissance systems that incorporate new and sophisticated techniques. One example of Melpar's leadership in this area is the conception, design, and production of one of the largest airborne electronic systems ever developed.

For details on provocative job openings in advanced scientific, engineering areas, write to: **Department I-8, Professional Employment Supervisor, 3610 Arlington Blvd., Falls Church, Virginia, in historic Fairfax County, 10 miles from Washington, D. C.**

An Arsenal of Technology

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Department T-1
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SWITCH and
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SEND FOR CATALOG 359A-1 *describing items above, also seals for circuit breakers, indicator lights and other electronic components.*

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Visit Our Booth 1229 at the IRE Show

Whom and What to See at the Radio Engineering Show

(Continued from page 148A)

Airpax Electronics Incorporated
Seminole Division
Ft. Lauderdale, Fla.
Cambridge Division
Cambridge, Md.
Booths 2306-2308

▲ H. A. Cook, ▲ D. H. Holdt, J. W. Sullivan, ▲ W. Heisler, W. Kouzoulas, ▲ D. A. Robinson, ▲ T. Dee, B. Linthicum, ▲ L. Gorder, M. Everhart, F. Marsh, J. Griffin, M. Rogers

Electro-magnetic circuit breaker

Electro-mechanical and transistor choppers*, electro-magnetic circuit breakers, magnetic amplifiers, power, audio and pulse transformers, frequency detectors, tachometers, stretch indicators*, demodulators, power amplifiers and meters. Hermetically sealed, miniature circuit breakers provide protection in critical circuits. Short or long time delays available, operation from DC, 60 & 400 CPS.

Airtron, Inc., Booths 1610-1618, 1709-1717
See: Litton Industries, Inc.

Aladdin Electronics Division, Aladdin Industries, Inc., Booth 1918
703 Murfreesboro Road
Nashville 10, Tenn.

F. G. Bassler, ▲ W. W. Stifler, ▲ P. E. Dicker, ▲ C. L. Freel

Ferrite Core Inductors, Miniature & Micro-Miniature Pulse Transformers, Wide-Band Transformers, High Quality I.F. Transformers, Missile I.F. Transformers.

Alden Electronic and Impulse Recording Equipment Co., Inc., Booth 1512
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Westboro, Mass.

Milton Alden, ▲ John Alden, Edward Cross, George Stafford, Lawrence Farrington

Direct Graphic Recording with Alden "Flying Spot" Component Recorders for instant tone shade recordings in scanning, sampling or time base data collection. Precision Graphic Recorder for underwater sound; Ceilometer Recorder for cloud height. Recorders for flaw detection. Spectrum Analysis, Radar, Infrared, Sonic, and Ultrasonic.

Alden Products Co.
117 N. Main St.
Brockton 64, Mass.
Booths 1508-1510

Russell Hawkins

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PRODUCTS COMPANY

Building Block Components to Mount, House, Fasten, Connect and Monitor Electronic and Electrical Circuitry. Plug-In Chassis and Miniature Circuit Packages, Terminals and Cards, Cabinets, Miniature Indicating Lights, "IMI" Connectors, Detachable Line Cords.

(Continued on page 154A)

last year
at the IRE Show
RIDER
introduced
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TRANSISTORIZED
CIRCUITS FOR
DIGITAL COMPUTERS

this year
see the fabulous
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A
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B
ALUMINUM
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A. Custom Line. Removable multi-panel, cowlings (19" width increments). Custom appearance for series mounting—space-saving and ideal for complex consoles. Double channel 16 gauge steel. Meets EIA standards.

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High Quality

High Performance

Extreme Reliability

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Conservatively rated at 40 and 22 amperes
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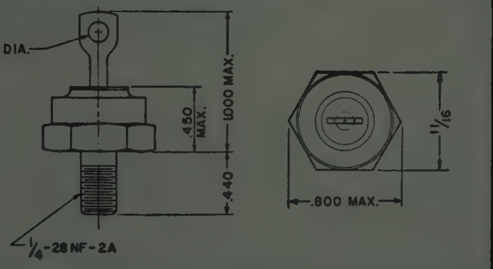

TYPE	AVG. DC CURRENT	PIV	NORMAL MAX. TEMP.	MAX. FORWARD DROP	MAX. REVERSE CURRENT
1N1191A	22A	50V	150°C	1.2V at 60 amps.	5.0 MA
1N1192A	22A	100V	150°C	1.2V at 60 amps.	5.0 MA
1N1193A	22A	150V	150°C	1.2V at 60 amps.	5.0 MA
1N1194A	22A	200V	150°C	1.2V at 60 amps.	5.0 MA
1N1183A	40A	50V	150°C	1.1V at 100 amps.	5.0 MA
1N1184A	40A	100V	150°C	1.1V at 100 amps.	5.0 MA
1N1185A	40A	150V	150°C	1.1V at 100 amps.	5.0 MA
1N1186A	40A	200V	150°C	1.1V at 100 amps.	5.0 MA at 150° C case temperature and rated PIV

For full information and applications assistance, contact your Delco Radio representative.

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AVAILABLE FEATURES:
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Whom and What to See at the Radio Engineering Show

(Continued from page 152A)

Alfax Paper and Engineering Co., Booth 1514
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M. Alden, S. C. Sviokla, E. D. Cross

Instantly visible graphic recording paper, records everything from faintest trace signal (micro second duration) to slow beat saturated signal, all simultaneously, electricity the ink—its intensity the shading control. Fastest eye-brain interpretation of records now possible. Tone shades make record easily distinguishable by eye for greater scientific interpretation.

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Transmission Line Hybrids, Coaxial Switches, Tapered Reducers, RF Loads, Line Stretchers, Adjustable Matching Networks, Antennas, Attenuators, Slotted Lines & Automatic Impedance Plotters.

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Power supplies for microwave devices, microwave amplifiers, microwave sweep oscillators, microwave power levelers.

Alite Div., Booths 2205-2207
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Complete Antenna Systems from ULF to Microwave. Special Purpose Antennas, Towers, and Rotators. Research, design, development, and production facilities. Systems consulting.

(Continued on page 156A)

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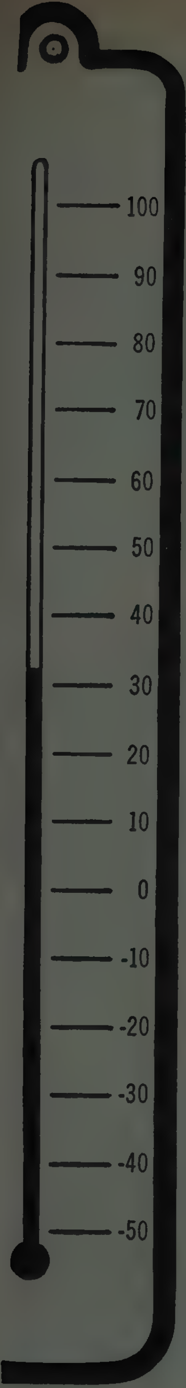

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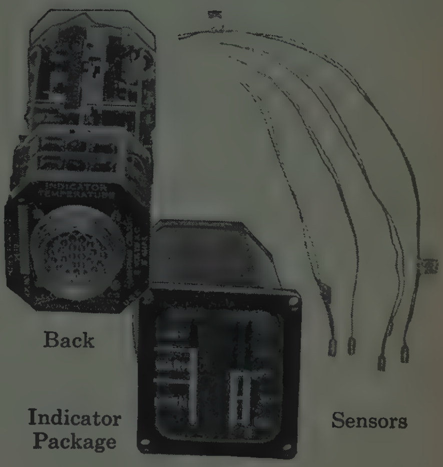
How do you take the temperature of an electronic system?

Use ONE Compact, Accurate, Lightweight, Completely Transistorized Oster-Developed Temperature Indicating System. Replaces 6 Indicating Systems.

The device illustrated senses and displays the highest of 4 temperature sensor signals on the Convair B-58 supersonic bomber. It also reads out the temperature of the plane's 2 refrigeration systems. However, the unit can monitor temperature of any military or commercial electronic system. Special versions can be furnished to monitor any analog voltage signal.



Oster®

Entire unit (component parts illustrated) has an accuracy of 1½%, weighs only 3.85 lbs. max., requires only 2⅜″ panel space, and does the work of 6 indicating systems. Component parts consist of 4 sensors, a computer package with 6 channels, and a hermetically sealed indicator package.

The unit is typical of Oster designed equipment.

Computer Package

For help with your instrumentation and display problems, talk to the specialists at the Avionic Division.

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Resolvers
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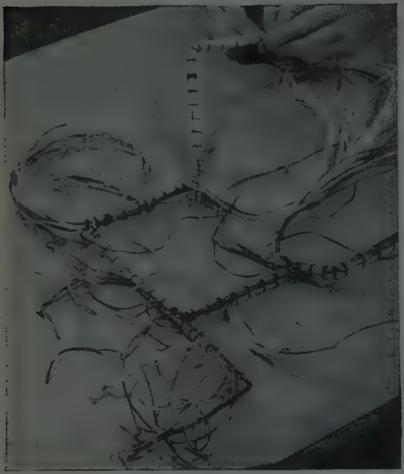

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Write for Data Book with specifications on Gudelace and Gudebrod's complete line of braided lacing tapes and dial cords—Temp-Lace, Stur-D-Lace, and Gude-Glass.

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Whom and What to See at the Radio Engineering Show

(Continued from page 154A)

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Silicon in all forms—Densified Chunk, Billets, Cast Rods, Seeds, Doping Alloys, Single Crystals, Slices and Special Forms.

Allegheny Ludlum Steel Corp., Booths 2509–2515
See: The Arnold Engineering Co.

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Booths 2314-2316

▲ Wm. W. Garstang, ▲ George W. Vater, A. Pfister, C. Dickinson, H. Zabel, ▲ B. Tellkamp, ▲ H. Schlicke, ▲ E. Schwartz, R. Hower, ▲ B. Budny, P. Leow

Subminiature components; rectilinear adjustable fixed resistors; narrow band pass filter for UHF telemetry frequencies; ferrites; ceramic capacitors; ceramic filters; fixed composition and metal film precision resistors.

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Complete line of Baker & Adamson® Electronic Grade Chemicals.

Allied Control Co., Inc., Booths 2905–2907
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Relays, Switches, Solenoid Valves. Featuring new Subminiature Relays: *6PDT and *4PDT Printed Circuit and *DPDT Sensitive. Also complete line of Subminiature, Miniature and Power Relays. Subminiature Single and Double Pole Toggle and *3-Pole Push-Button Switches. Solenoid Valves: 2- and 3-Way and Metering.

Allied Radio Corp., Booths 3915–3917
See: Knight Electronics Corp.

Alpha Metals, Inc., Booth 4328
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Jersey City 4, N.J.

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Robert C. Komarek

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Systems Capabilities of Arma Division, Micro-Miniaturization Advances in Digital Computer Components & Packaging, Lightweight Electric Motors and Heavy Duty Motors Produced by American Bosch Division, and Representative Products of Other American Bosch Arma Divisions.

(Continued on page 159A)

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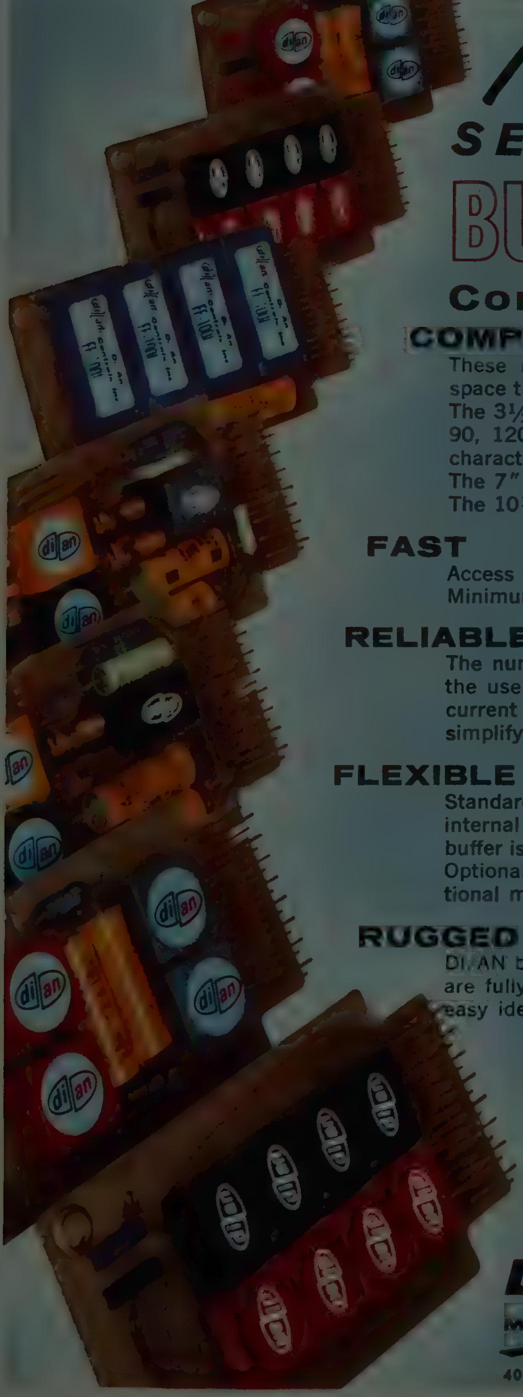
di/an
Di/An Controls, Inc.



New...

SEQUENTIAL ACCESS BUFFER STORAGE

Compact · Reliable · Rugged

COMPACT

These new designs make possible greater storage capacity in less space than ever before.

The 3½″ unit (shown above) provides standard capacities of 36, 72, 90, 120, 126, 144, 210 and 240 characters, with 4 to 12 bits per character.

The 7″ panel height accommodates up to 1,560 characters.

The 10½″ unit accepts a total of 4,032 characters.

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Access time of 2 microseconds.

Minimum character loading or unloading time is 5 microseconds.

RELIABLE

The number of transistors and diodes is held to a minimum through the use of magnetic logic. The advanced design of these coincident-current buffer storages uses only two power supply voltages thus simplifying power needs and circuitry.

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Optional — Electronic clear and reset, multiple field selection, additional marker pulses and automatic read-write mode.

RUGGED

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DI/AN Controls offers a complete line of coincident-current magnetic core buffer storages for single block storage, non-destructive readout, format changing for card punch and rotary bar printer, and sorting applications. *Send for complete information about these space saving, ruggedized, buffer storages.*

36
72
90
120
126
144
210
240

336
420
462
594
702
864
924
1080
1122
1254
1326
1560

1638
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3192
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4032

DI/An Controls, Inc.

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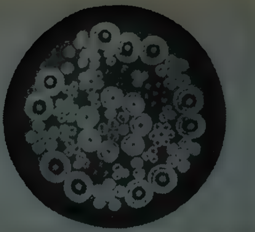
HIGH TEMPERATURE

CABLE CAPABILITIES

Our experienced Design Engineers specialize in cable and cable assemblies utilizing Teflon® insulated hook-up wire (large and small), solid core and air dielectric coaxial cable, shielded and jacketed multi-conductors—or any combination of these.

Many leading aircraft and electronic manufacturers are taking advantage of Tensolite's cable design and production facilities. Let us work with you in translating your requirements into highly reliable jumbo cables and cable assemblies.



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WIRE AND CABLE

HOOK-UP Wire—Mil Spec & Thin Wall

Teflon – Extruded, Spiral Wrapped, and FLEXOLON wire
Types E-EE to MIL-W-16878 and NAS-703 (−90° to +250°C)

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Super-flexible wire (−40° to +60°C)

COAXIAL CABLE

Solid Core and Air Dielectric
Designed to MIL-C-17B
RG Specs. (−90° to +250°C)

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Standard and Custom Designed to Military and Industrial Specs.

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- Asbestos Wire to MIL-C-25038
- Antenna Wire
- Low Capacitance Cable
- Wire Coated with Teflon (100X) FEP Resin
- Tone Arm Wire
- Ribbon Cable Shielded and Unshielded
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Whom and What to See at the Radio Engineering Show

(*Continued from page 156A*)

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Booth 4033

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Our display will feature our complete line of American Beauty Electric Soldering Irons and Accessories—including our *NEW 50-WATT "Bantam X" Series Soldering Irons in 1/8" and 3/16" tip-sizes featuring scientifically-vented casings in straight or angle type, hotter tips and cooler handles.

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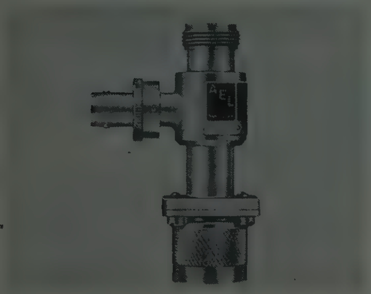
Booth 3935

Robert D. Freedman, Hamilton Priday, George Landfear, Maurice Polayes, Tom Burke



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See: William Brand—Rex Div.

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TITANIA DIVISION: R. B. Williams, Carl Day, E. Dudley Bell, J. D. Rivers

Multi-pin hermetically sealed headers, *special assemblies such as by-pass filter units for airborne military equipment, *high voltage and lightning arrester capacitors, thin alumina ceramic transistor platforms, *micro-modules and electron tube insulators, metal-ceramic combinations. (New and complex molded shapes.)

(*Continued on page 160A*)

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By E. Norman Lurch, *State Univ. of New York.* Covers the whole vast field on an intermediate level, equipping the reader with a working introduction to any area, including computer systems. *1960. 631 pages. $8.25*

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By J. Kaye *and* J. A. Welsh, *both of M.I.T.* Extends thermodynamics of irreversible processes to thermoelectricity, thermionic emission, direct conversion of heat to electricity. Reports on the thermoelectron engine and solid-state thermoelectric generators. *1960. Approx. 384 pages. Prob. $8.75*

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By L. P. Harris, *GE Research Laboratory.* Analyses for three flows of viscous, incompressible, electrically conducting fluids in high-aspect ratio rectangular channels, subjected to transverse magnetic fields. *A Technology Press Research Monograph, M.I.T. 1960. 96 pages. $2.75*

SPACE TECHNOLOGY

Edited by H. S. Seifert, *Space Technology Laboratories, Inc.* First to cover all phases seriously—ballistics and flight dynamics; propulsion; communications; man in space; scientific uses of space. *1959. 1188 pages. $22.50*

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By H. Chestnut *and* R. W. Mayer, *both of General Electric.* Starts with basic mathematics, describes nature of physical systems involved, then proceeds to solutions of advanced design. Many additions. *1959. 680 pages. $11.75*

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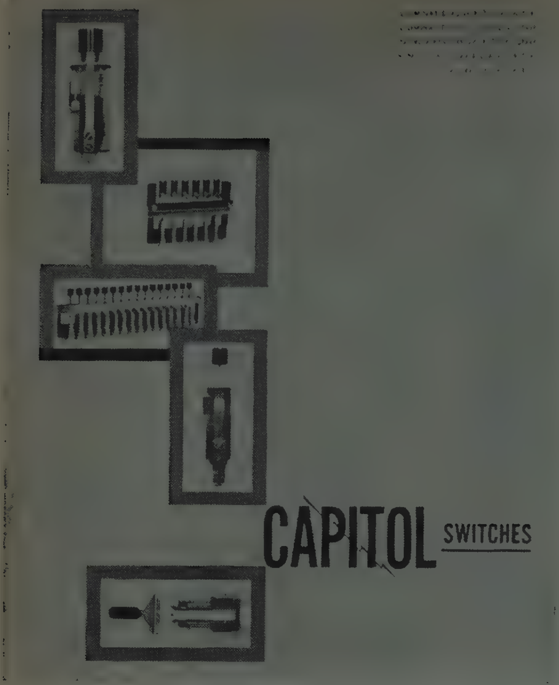

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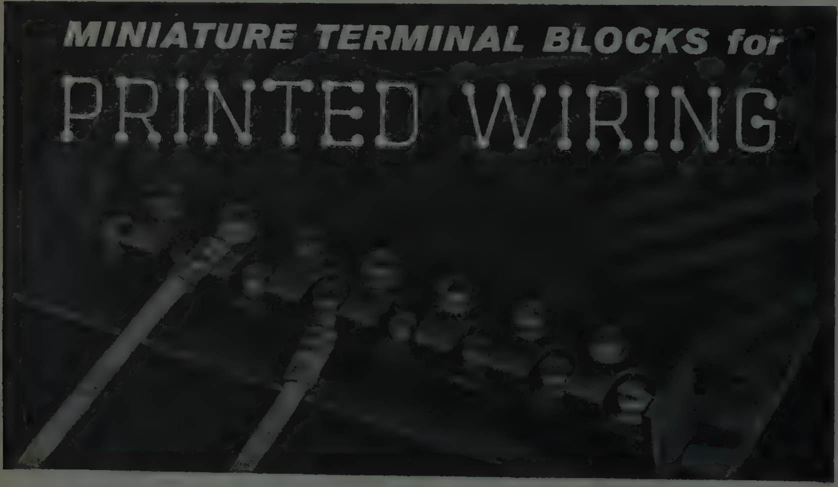

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(Continued from page 159A)

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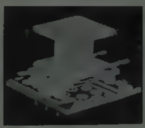

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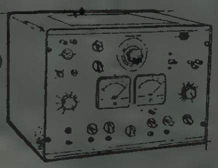

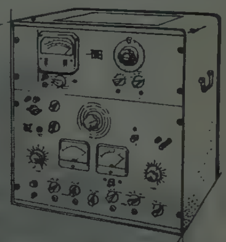

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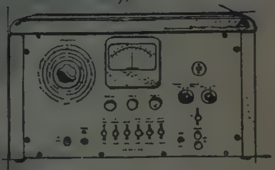

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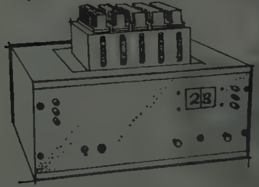

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(Continued on page 164A)

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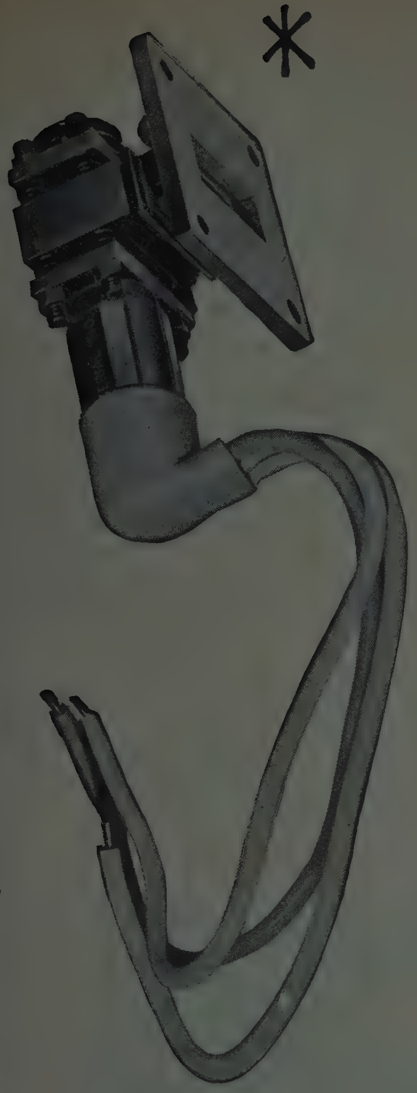

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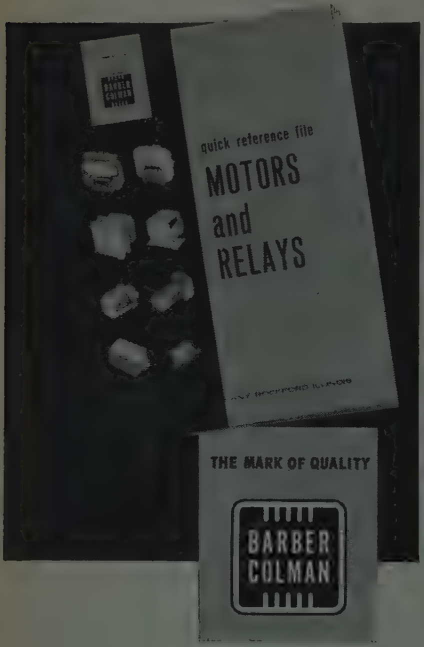

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(Continued on page 166A)

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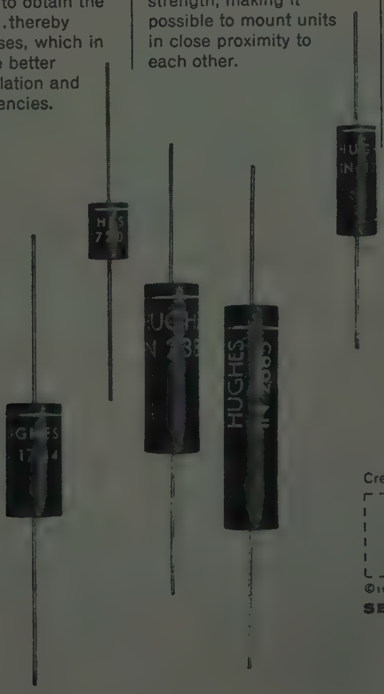

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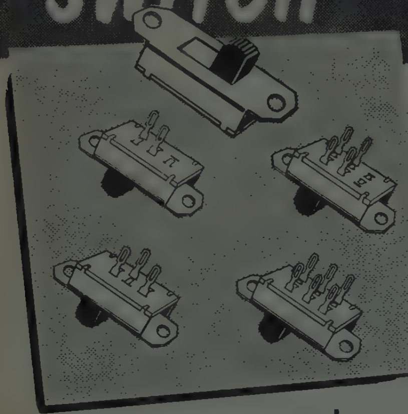

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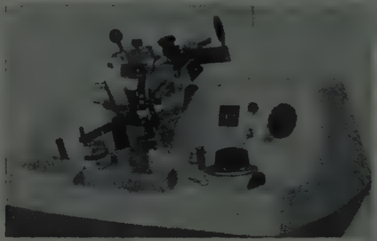

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(Continued on page 168A)

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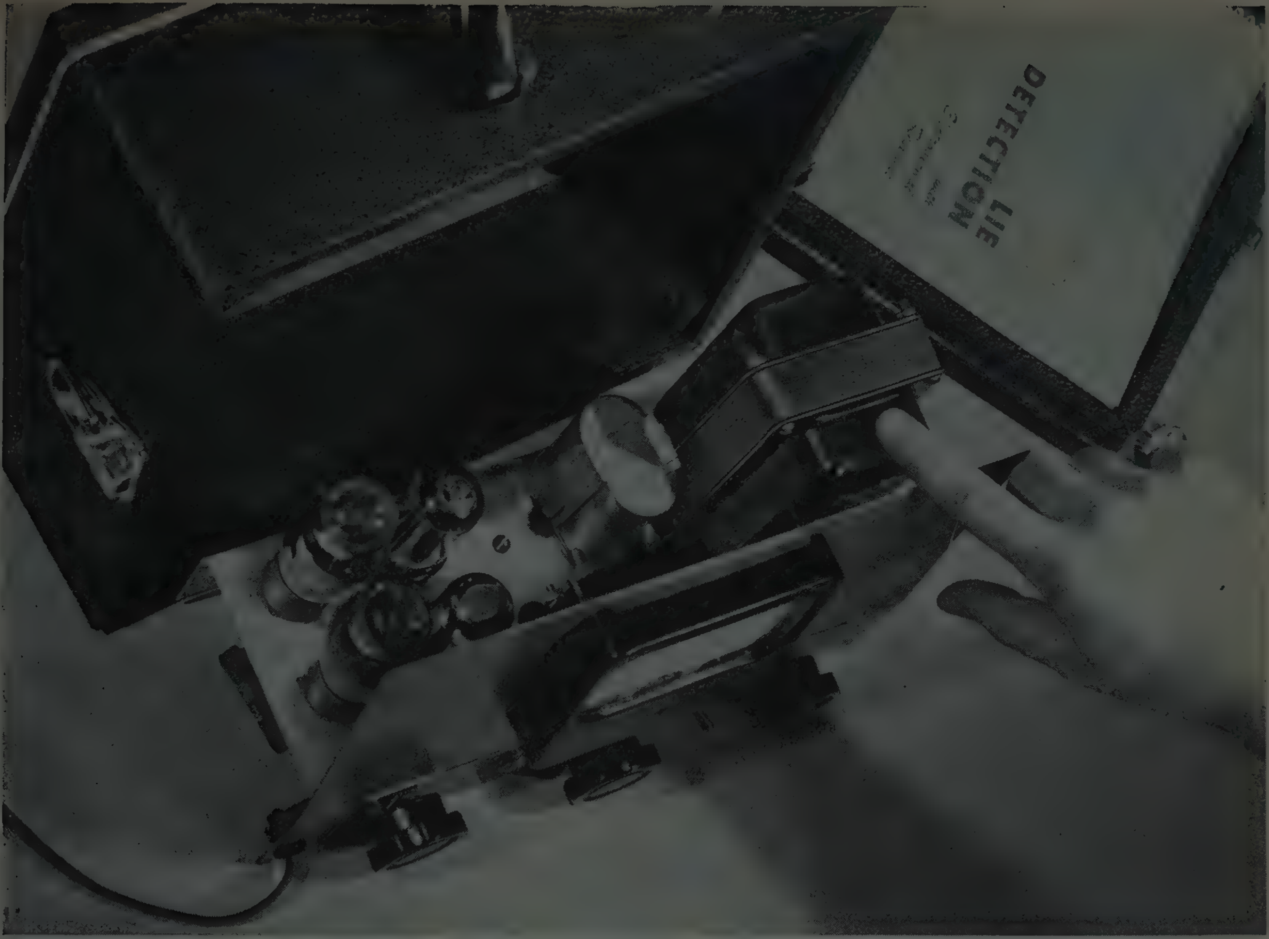

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(Continued from page 166A)

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Permanent magnets of Alnico and Arnox, Silectron transformer cores, high permeability tape wound cores of Deltamax, Permalloy, Supermalloy, Supermendur, as well as bobbin cores, Powder cores of Molybdenum Permalloy, carbonyl iron and Sendust; Barium titanate transducers; special magnetic materials.

Artos Engineering Co.
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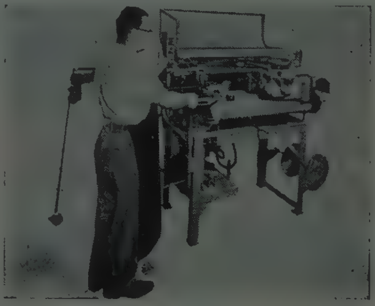
Milwaukee 46, Wis.
Booth 4205

Haakon T. Randar, Anders Moline, C. Terry, Sven Andersen, Patricia Harris



Combination automatic wire stripping and terminal attaching machine with continuous wire marking.

Assembly Products, Inc., Booths 3916-3918
75 Wilson Mills Road
Chesterland, Ohio

▲ John D. Saint-Amour, Robert H. Pugsley, George J. Crowdes, ▲ Lionel Glauberman, Dick McGinnis, Lou Issel, Bradley Thompson, Frank Mazzeo, Glen Krebs, Ivan I. Bezugloff, Jr., Jack Bayha, James McElroy

*Continuous Reading meter-relay; *new kind of contact-making wattmeter. Locking contact meter-relays, API panel meters, complete control packages; and panel-mounting electronic voltmeters made by a subsidiary, Metronix, Inc. (for monitoring applications in systems and consoles, an AC-DC model in half relay-rack mounting); also from Metronix portable equipment for testing transistors, vacuum tubes and other components.

(Continued on page 172A)

▲ Indicates IRE member.
* Indicates new product.

Lecture Halls in the Coliseum are located on the Fourth Floor. See complete program of speakers and papers in the front half of this book.

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FIRST MEZZANINE—
BOOTH M-1

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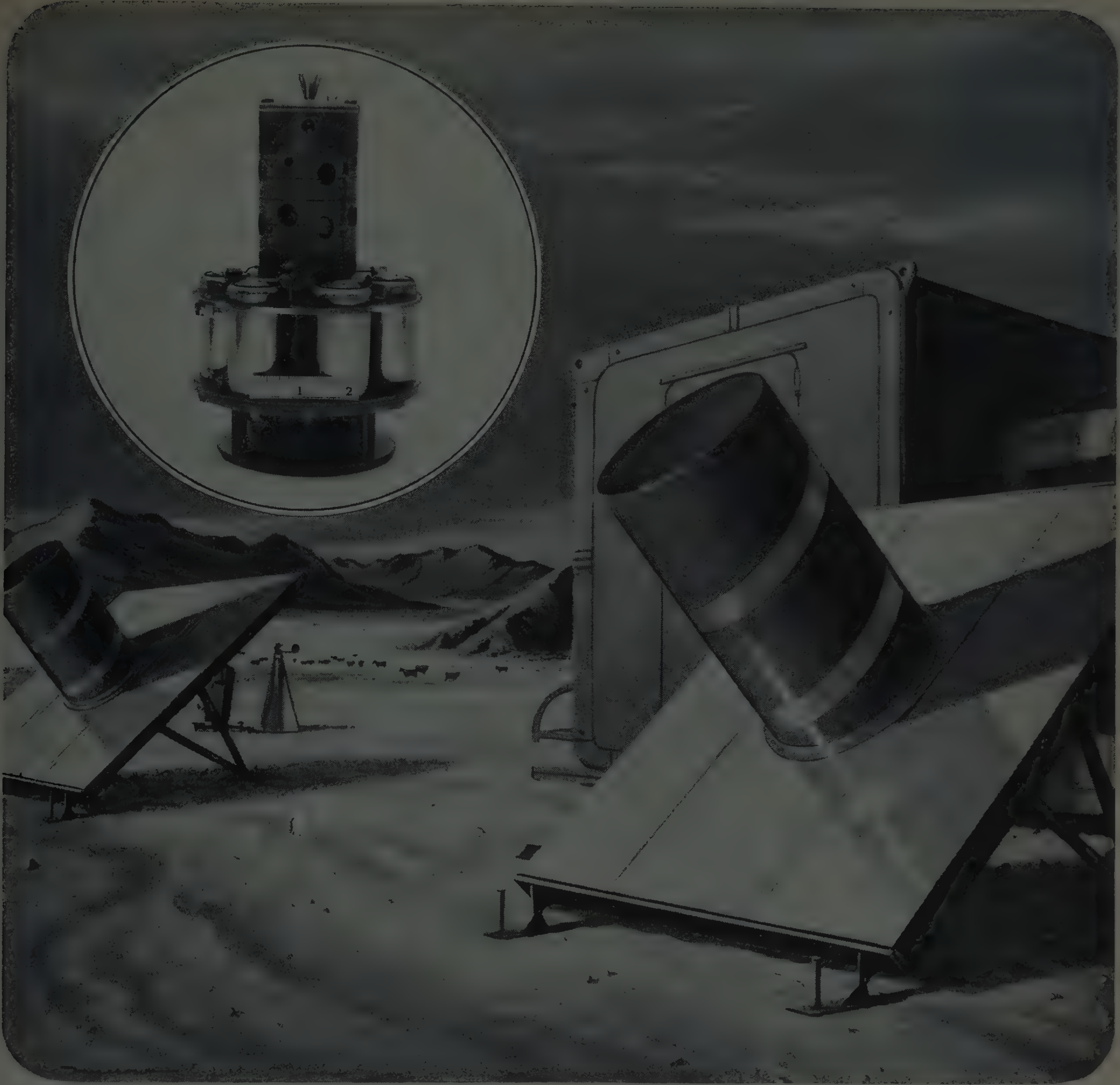
ELECTRONIC CORPORATION
READINGTON ROAD, NORTH BRANCH, N.J.
RAndolph 5-1000

NOTABLE ACHIEVEMENTS AT JPL...



From MICROLOCK to microlock

One of the most interesting and useful scientific activities at JPL has been the development of MICROLOCK, a radio tracking and communication system for satellites.

Microlock is designed to transmit information over extreme ranges of space with a minimal amount of transmitter power and weight. The objective was achieved by sophisticated design of the ground receiving equipment. The design utilizes basic electronic circuits and techniques carefully combined in a novel manner to provide superior performance and sensitivity.

The satellite transmitter consists of a radio-frequency oscillator, phase-modulated by telemetering signals, and radiates a power of 3 mW. It is capable of operating for several months on a battery weighing one pound.

Used successfully in previous space vehicles, microlock remains a useful and expandable instrument for continuing space exploration. It is a prime example of JPL's activity on the space frontier.

jpl

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JET PROPULSION LABORATORY
A Research Facility operated for the National Aeronautics and Space Administration
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98.5% survival

That's the life-test record of General Electric low-current

	FEATURES	JEDEC or G-E TYPE NO.	PIV.	MAXIMUM Idc at T°C	MAXIMUM 1 Cycle (60 cps) Surge	MAXIMUM Storage TEMP. °C
GERMANIUM LOW CURRENT	Alloyed junction type combining very low forward resistance with high back resistance	1N91	100	150ma at 55°amb.	25A	85°
		1N92	200	100ma at 55°amb.	25A	85°
		1N93	300	75ma at 55°amb.	25A	85°
		USN1N93	300	75ma at 55°amb.	25A	85°
	Single and double-fin units	1N151	100	500ma at 55°amb.	25A	85°
		1N152	200	500ma at 55°amb.	25A	85°
		1N153	[illegible]0	500ma at 55°amb.	25A	85°
		1N158	380	500ma at 55°amb.	25A	85°
	Designed for high operating temperatures and low reverse current	1N315	100	100ma at 85°amb.	5A	95°
		USAF1N315	100	100ma at 85°amb.	5A	100°
		1N368	200	100ma at 85°amb.	10A	85°
SILICON LOW CURRENT	Designed for maximum forward conductance at high operating temperatures (165°C)	1N536	50	500ma at 100°amb.	15A	175°
		1N537	100	500ma at 100°amb.	15A	175°
		1N538	200	500ma at 100°amb.	15A	175°
		USAF1N538	200	500ma at 100°amb.	15A	175°
		1N539	300	500ma at 100°amb.	15A	175°
		1N540	400	500ma at 100°amb.	15A	175°
		USAF1N540	400	500ma at 100°amb.	15A	175°
		1N547	600	500ma at 100°amb.	15A	175°
		1N1095	500	425ma at 100°amb.	15A	175°
		1N1096	600	350ma at 100°amb.	15A	175°
	Similar to 1N536 series but with very low reverse current. Ideal for magnetic amplifier applications.	1N440	100	300ma at 100°amb.	15A	175°
		1N440B	100	500ma at 100°amb.	15A	175°
		1N441	200	300ma at 100°amb.	15A	175°
		1N441B	200	500ma at 100°amb.	15A	175°
		1N442	300	300ma at 100°amb.	15A	175°
		1N442B	300	500ma at 100°amb.	15A	175°
		1N443	400	300ma at 100°amb.	15A	175°
		1N443B	400	500ma at 100°amb.	15A	175°
		1N444	500	300ma at 100°amb.	15A	175°
		1N444B	500	425ma at 100°amb.	15A	175°
		1N445	600	300ma at 100°amb.	15A	175°
		1N445B	600	350ma at 100°amb.	15A	175°
	Less expensive versions of 1N536 series for lower temperatures (140°C)	1N1487	100	370ma at 100°amb.	15A	150°
		1N1488	200	370ma at 100°amb.	15A	150°
		1N1489	300	370ma at 100°amb.	15A	150°
		1N1490	400	370ma at 100°amb.	15A	150°
		1N1491	500	300ma at 100°amb.	15A	150°
		1N1492	600	250ma at 95°amb.	15[illegible]	150°
	Lower current and temperature operation (100°C) than any of above series; very economical	1N1692	100	600ma at 100°C amb.	20A	125°
		1N1693	200	600ma at 100°C amb.	[illegible]	125°
		1N1694	300	600ma at 100°C amb.	20A	125°
		1N1695	400	600ma at 100°C amb.	20A	125°
	Similar to 1N440B series	1N1100	100	500ma at 100°amb.	15A	175°
		1N1101	200	500ma at 100°amb.	15A	175°
		1N1102	300	500ma at 100°amb.	15A	175°
		1N1103	400	500ma at 100°amb.	15A	175°
	1N599 series similar to 1N540 series; 1N599A series similar to 1N440B series. Forward current ratings are somewhat lower.	1N599(A)	50	400ma at 100°amb.	10A	175°
		1N600(A)	100	400ma at 100°amb.	10A	175°
		1N601(A)	1[illegible]0	400ma at 100°amb.	10A	175°
		1N602(A)	200	400ma at 100°amb.	10A	175°
		1N603(A)	300	400ma at 100°amb.	10A	175°
		1N604(A)	400	400ma at 100°amb.	10A	175°
		1N605(A)	500	400ma at 100°amb.	10A	175°
		1N606(A)	600	400ma at 100°amb.	10A	175°
SILICON LOW CURRENT	Same as 1N540 series except stud mounted; maximum forward conductance at high operating temperatures	1N1115	100	1.5A at 85°stud.	15A	175°
		1N1116	200	1.5A at 85°stud.	15A	175°
		1N1117	300	1.5A at 85°stud.	15A	175°
		1N1118	400	1.5A at 85°stud.	15A	175°
		1N1119	500	1.5A at 85°stud.	15A	175°
		1N1120	600	1.5A at 85°stud.	15A	175°
	One of the first stud series, JAN1N256 units available	1N253	95	1000ma at 135°stud.	4A	150°
		1N254	190	400ma at 135°stud.	1.5A	150°
		1N255	380	400ma at 135°stud.	1.5A	150°
		1N256	570	200ma at 135°stud.	1.5A	150°
	Same as 1N440B series, except stud mounted; extremely low reverse current; well suited for magnetic amplifiers	1N550	100	800ma at 135°stud.	15A	175°
		1N551	200	800ma at 135°stud.	15A	175°
		1N552	300	800ma at 135°stud.	15A	175°
		1N553	400	800ma at 135°stud.	15A	175°
		1N554	500	600ma at 135°stud.	15A	175°
		1N555	600	600ma at 135°stud.	15A	175°

at 25,000 hours!

germanium rectifiers (Type 1N92); and silicon (Type 1N538) is even higher for 10,000 hours

General Electric low-current rectifiers have earned a reputation for reliability without equal in the industry. The table below is just a sample of the numerous life test studies which prove out the superior reliability *built into* all G-E rectifiers.

Maximum Forward Conductance

General Electric low-current silicon and germanium rectifiers are designed for maximum forward conductance at high operating temperatures. High current loads are carried *without* external heat sinks. Reverse current at maximum junction temperature is maintained at an extremely low level, making these devices ideal for low-leakage applications.

Minimum Forward Voltage Drop

Minimum forward voltage drop and a hermetically sealed case have combined to produce low-current rectifiers whose reliability exceeds all known existing MIL specs. A comparative study shows that these G-E devices have the highest resistance to thermal runaway at maximum full-load operating temperatures of those products tested.

Choose the performance range you require from one of the most comprehensive low-current rectifier lines in the industry (see chart at left). Complete specifications are available from your General Electric Distributor or G-E Semiconductor District Sales Office. In Canada: Canadian General Electric Co., 189 Dufferin St., Toronto, Ontario. Export: International General Electric Co., 150 E. 42nd Street, New York, N. Y.

General Electric rectifiers are in stock at your local G-E Distributor

Survival Data From Operating and Elevated Storage Tests

Type of Unit	PIV	Current (ma)	Type of Test	No. of Units	*Percent Survival
1N92 Germanium	200V	100	Operating at full load	69	98.5 @ 25,000 hrs.
1N538 Silicon	200V	250	Operating at full load plus elevated storage life	83	99 @ 10,000 hrs.

$$\text{*Percent survival} = \frac{\text{no. of good units}}{\text{total no. tested}} \times 100$$

	FEATURES	JEDEC or G-E TYPE NO.	PIV.	MAXIMUM Idc at T°C	MAXIMUM 1 Cycle (60 cps) Surge	MAXIMUM Storage TEMP. °C
SILICON LOW CURRENT	A widely used line similar in most respects to 1N1115 series	IN332	400	400ma at 150°stud.	15A	170°
		IN333	400	200ma at 150°stud.	10A	170°
		IN334	300	400ma at 150°stud.	15A	170°
		IN335	300	200ma at 150°stud.	10A	170°
		IN336	200	400ma at 150°stud.	15A	170°
		IN337	200	200ma at 150°stud.	10A	170°
		IN339	100	400ma at 150°stud.	15A	170°
		IN340	100	200ma at 150°stud.	10A	170°
		IN341	400	400ma at 150°stud.	15A	170°
		IN342	400	200ma at 150°stud.	10A	170°
		IN343	300	400ma at 150°stud.	15A	170°
		IN344	300	200ma at 150°stud.	10A	170°
		IN345	200	400ma at 150°stud.	15A	170°
		IN346	200	200ma at 150°stud.	10A	170°
		IN348	100	400ma at 150°stud.	15A	170°
		IN349	100	200ma at 150°stud.	10A	170°
	1N607 series similar to 1N115 series; 1N607A series similar to 1N550 series	IN607(A)	50	800ma at 135°stud.	15A	170°
		IN608(A)	100	800ma at 135°stud.	15A	170°
		IN609(A)	150	800ma at 135°stud.	15A	170°
		IN610(A)	200	800ma at 135°stud.	15A	170°
		IN611(A)	300	800ma at 135°stud.	15A	170°
		IN612(A)	400	800ma at 135°stud.	15A	170°
		IN613(A)	500	600ma at 135°stud.	15A	170°
		IN614(A)	600	600ma at 135°stud.	15A	170°
SILICON MEDIUM CURRENT	Stud Mounted Cells. Designed for 2 to 20 ampere range. High junction temperature ratings, very low forward voltage drop and thermal resistance.	IN2154	50	25A at 145°stud.	300A	200°
		IN2155	100	25A at 145°stud.	300A	200°
		IN2156	200	25A at 145°stud.	300A	200°
		IN2157	300	25A at 145°stud.	300A	200°
		IN2158	400	25A at 145°stud.	300A	200°
		IN2159	500	25A at 145°stud.	300A	200°
		IN2160	600	25A at 145°stud.	300A	200°

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At the 1960 IRE Show and Convention, for
IMPRESSIVE, IMPORTANT NEW DEVELOPMENTS IN THE MOST RELIABLE ELECTRICAL TERMINAL BLOCKS
The TWIN-LOCK T-1000 top entry and T-1010 side entry.
TWIN LOCK INCORPORATED

Whom and What to See at the Radio Engineering Show

(Continued from page 168A)

Associated American Winding Machinery, Inc., Booths 4228-4230
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New York 56, N.Y.

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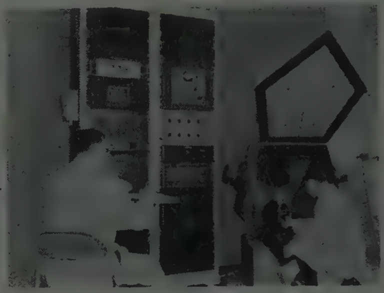
Booths 3830-3832

Bernard Novack. William Tonkowich, Robert Goldsmith, Frank Keena, Bernard Brodsky, Nelson Burack, Jack Bystrom, Albert F. Erdman, John E. Stryker, Daniel N. Schochet

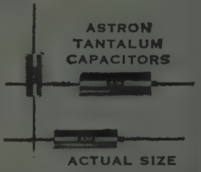


Acoustic Noise Test Facility*

Manufacturing Division: Manufacturer of environmental test chambers and equipment for acoustic noise*, sawtooth shock*, auxiliary vibration (slippery tables)*, temperature-humidity (cascade and liquid CO_2), salt spray (all-Lucite). Testing Divisions: Environmental Testing Divisions, located at Caldwell N.J. and Orlando, Florida, performing environmental and reliability testing.

Astron Corp.
255 Grant Ave.
East Newark, N.J.
Booth 2602

I. I. Ser, ▲P. M. Maler, R. Black, A. Burton, A. Merola, J. Gordon, R. Mottola, A. Walker, ▲H. Mutz, J. Barg, L. Busch, A. Gordon, I. Lubin, E. Pataki, R. Heller



Solid Tantalum, Metallized Mylar,® Mylar® Dielectric, Electrolytic, Mil-C-25A Paper, Metallized Paper, RF Noise Suppression Filters, and Ceramic Capacitors (Skottie Electronics, Inc.).

Atlas E-E Corp., Booth 4222
See: Atlee Corporation

Atlee Corporation, Booth 4222
47 Prospect St.
Woburn, Mass.

▲Allan Q. Mowatt, Dan E. Baker, Frank T. McAvoy, Leverett A. Martel

Trimmer capacitors, heat dissipating tube shield, full contact insert for tube shields, transistor clips and heat sinks, standard and special clips and holders for all types of components.

(Continued on page 174A)

▲ Indicates IRE member.
* Indicates new product.

Microwave Component News
from SYLVANIA

Lower relay equipment operating costs with new Sylvania Klystrons

Metallurgical and processing improvements mean superior life and performance

Sylvania's research and production capabilities have produced a series of klystrons that promise to surpass earlier types in performance.

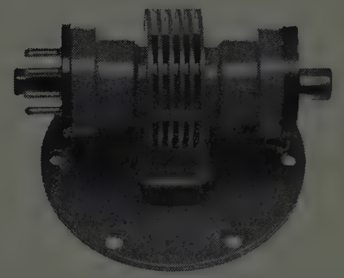
Sylvania's klystrons have the following features:

Improved high-temperature glass seal – this permits higher bake-out temperatures and gives a lower gas level. The resulting tubes have a life expectancy of 10,000 hours, 2,000 hours longer than competitive types, and better shelf life. This means lower operating costs for relay link equipment.

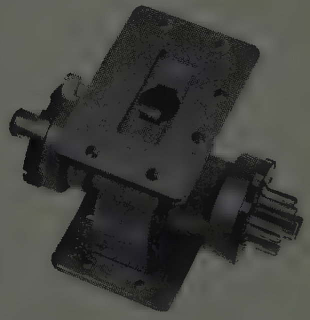
Purer metals and materials – the premium quality metals used in these tubes, combined with new, exacting processing techniques permit higher bake-out temperatures and result in longer trouble-free operation with low gas levels.

Superior performance – full coverage from 5925 to 8100 mc with 1 watt nominal output power. Most of these tubes have a minimum electronic bandwidth of 28 mc.

Sylvania klystrons will give you added cost savings because of their longer life and fewer early-life failures. Send for the data.



SK-220B, shown approx. ⅓ actual size.
Fins facilitate forced-air cooling.



SK-222D, shown approx. ½ actual size.
Flange connects to heat sink.

Forced air cooled	Conduction cooled	Frequency
SK-220F	SK-222F	5925-6225 mc
SK-220E	SK-222E	6125-6425 mc
SK-220G	SK-222G	6425-6575 mc
SK-220D	SK-222D	6575-6875 mc
SK-220C	SK-222C	6875-7125 mc
SK-220B	SK-222B	7125-7425 mc
SK-220A	SK-222A	7425-7750 mc
SK-220Z	SK-222Z	7750-8100 mc

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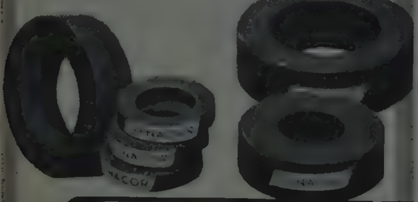
Dynacor Square-Loop Tape Cores are manufactured with the high permeability alloys—Grain-Oriented 50-50 Nickel Iron, 4-79 Molybdenum Permalloy, and Grain-Oriented 3% Silicon Iron . . . with fully guaranteed uniformity . . . under rigid standards of control and inspection.

Look to Dynacor for reliable production and swift delivery of your tape core requirements. For your convenience a full line of standard units are stocked for immediate off-the-shelf delivery—Send for bulletins DN 2000, DN 2001, DN 2002.



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Whom and What to See at the Radio Engineering Show

(Continued from page 172A)

Audio Development Co.
2833 Thirteenth Ave., South
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Booth 1623

▲ W. E. Lehnert, ▲ L. A. Robert, D. E. Engebretson, D. G. Watson

Transformers, filters, toroids, reactors, telephone coils, transformers for printed circuits, transformers for use with high powered transistors, telephone type plugs, jacks, jack panels, terminal blocks—all sizes.

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Booth 4504

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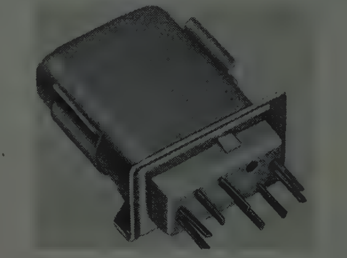

Component clips, transistor clips, Heat dissipating tube shield (sub-miniature), Crystal socket clip assembly, *sub-miniature relay socket assembly, panel mounting brackets, sub-miniature tube cradle and socket assemblies, potentiometer clamp rings, servo motor clamp rings, tube clamps, custom metal stampings.

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Northlake, Ill.
Booths 1906-1908

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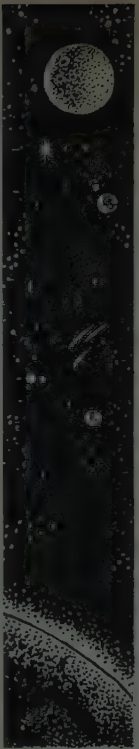
Class E Relay with Taper Tab Terminals

Telephone-type relays and rotary stepping switches, open or hermetically sealed, for industrial control applications. Also components, sub-assemblies and complete control systems.

(Continued on page 176A)



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FOR
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INSTRUMENTS • AUTOMATION

ONE Source of supply for FASTENINGS

SCREWS
NUTS
BOLTS
WASHERS
RIVETS
EYELETS
TERMINALS
GROMMETS
ACCESSORIES

We carry in stock thousands of STANDARD and SPECIAL items essential to the INSTRUMENT, ELECTRONIC and AUTOMATION Mfg. industry.

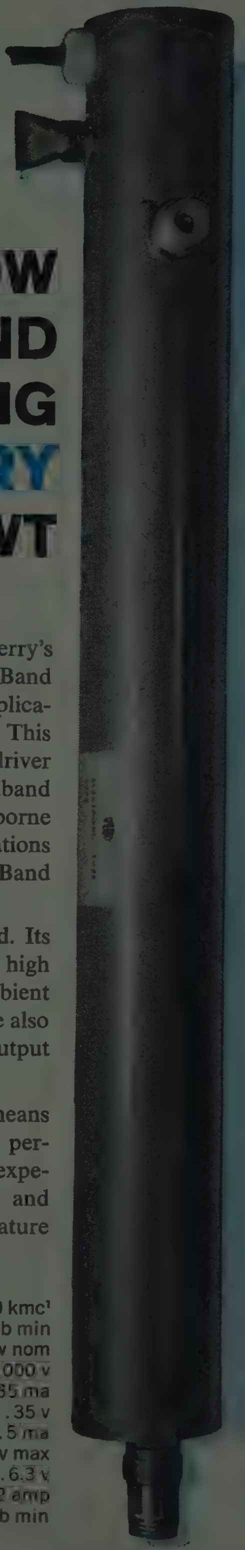
Special Cold Headed Products
Stampings
Screw Machine Parts
Made to order in all metals.

Write for Catalog #60

FEDERAL Screw Products Inc.
3917 N. Kedzie Ave., Chicago 18, Ill.

Be
Sure
To
Visit

SPERRY MICROWAVE TUBE CLINIC—IRE SHOW
March 21-24, Booths #2432-2438
Bring your problems involving microwave tubes
and discuss them with our engineers at this Sperry Clinic.



NOW 60DB GAIN IN L-BAND PPM FOCUSING NEW SPERRY STL-222 TWT

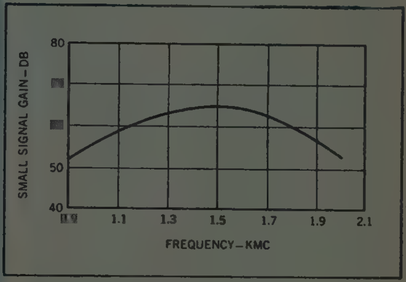
. . . cuts Space, Weight, Cost, Power Requirements — Sperry's new STL-222 provides twice the gain of ordinary L-Band tubes—actually takes the place of two tubes in most applications — yet is only 20″ long, weighs only 8.5 pounds. This important advantage suits this new CW amplifier and driver perfectly to airborne applications. Its excellent broadband stability recommends it for ground support and airborne radar equipment . . . communications . . . drone applications . . . noise generators . . . switching devices and other L-Band uses.

The STL-222 is periodic permanent magnet focused. Its tough metal and ceramic construction provides for high environmental capability, stable operation at high ambient temperatures and under extremes of vibration. This tube also features a high-mu modulating grid and high input-to-output isolation. It is short circuit stable.

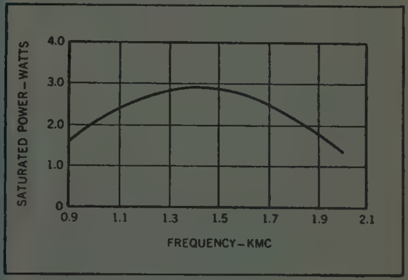
The STL-222 is now in production at Sperry, which means lower unit cost and fast delivery schedules. Advanced performance and dependability result from Sperry's long experience in klystron and TWT research, development and production. Write for complete data, outlining the nature of your application.

Specifications

Frequency Range	1.0 to 2.0 kmc[1]
Small-signal gain	48 db min
Saturated Power Output	2 w nom
Beam Voltage	1000 v
Beam Current	35 ma
Grid Bias	35 v
Grid Current	5 ma
Grid Cut-off Signal	—20 v max
Heater Voltage	6.3 v
Heater Current	3.2 amp
Input-Output Isolation	75 db min



Small-Signal Gain vs. Frequency



Saturated Power vs. Frequency

SPERRY

PERRY ELECTRONIC TUBE DIVISION, *SPERRY RAND CORPORATION, GAINESVILLE, FLORIDA*
ddress inquiries: Gainesville, or Sperry Offices in Brooklyn • Boston • Philadelphia • Chicago • Los Angeles • Montreal • Export Dept., Great Neck, N.Y.

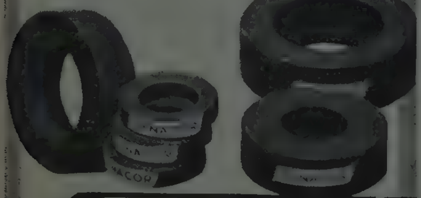
See us at the IRE Show, Booth 4020

SQUARE-LOOP TAPE CORES TO MEET YOUR *TOUGHEST* SPECIFICATIONS

Speed your specs to Dynacor when you want square-loop tape cores *to exact requirements—fast!* Here you'll find a dependable combination of personnel, experience and facilities—the know-how to deliver parameters to your very tightest tolerance requirements for switching time, flux, and noise.

Dynacor Square-Loop Tape Cores are manufactured with the high permeability alloys—Grain-Oriented 50-50 Nickel Iron, 4-79 Molybdenum Permalloy, and Grain-Oriented 3% Silicon Iron . . . with fully guaranteed uniformity . . . under rigid standards of control and inspection.

Look to Dynacor for reliable production and swift delivery of your tape core requirements. For your convenience a full line of standard units are stocked for immediate off-the-shelf delivery—Send for bulletins DN 2000, DN 2001, DN 2002.



DYNACOR®

DYNACOR, INC.
A SUBSIDIARY OF SPRAGUE ELECTRIC CO.
WESTMORE AVENUE, ROCKVILLE, MARYLAND

Whom and What to See at the Radio Engineering Show

(Continued from page 172A)

Audio Development Co.

2833 Thirteenth Ave., South
Minneapolis 7, Minn.

Booth 1623

▲ W. E. Lehnert, ▲ L. A. Robert, D. E. Engebretson, D. G. Watson

Transformers, filters, toroids, reactors, telephone coils, transformers for printed circuits, transformers for use with high powered transistors, telephone type plugs, jacks, jack panels, terminal blocks—all sizes.

Audio Devices, Inc., Booth 2519
444 Madison Ave.
New York 22, N.Y.

H. Kornbrodt, R. Hickey, J. Puttre, G. Kulper, G. S. Johnson, B. N. Freifeld, R. Haag

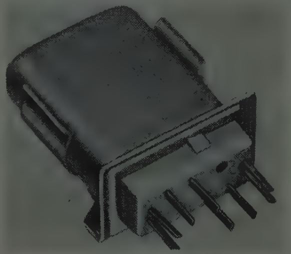
Type EP AUDIOTAPE—extra precision magnetic recording tape for computers, telemetering, automation, seismography. The complete line of Audiotape for every sound recording need. Audiodiscs, Audiofilm.

Augat Bros., Inc.

31 Perry Ave.
Attleboro, Mass.

Booth 4504

E. H. Augat, N. F. Damon, C. E. Kiefer, R. C. Hoy, R. S. Laurence, W. H. Sonkin, H. Morrell, D. Sonkin



Component clips, transistor clips, Heat dissipating tube shield (sub-miniature), Crystal socket clip assembly, *sub-miniature relay socket assembly, panel mounting brackets, sub-miniature tube cradle and socket assemblies, potentiometer clamp rings, servo motor clamp rings, tube clamps, custom metal stampings.

Automatic Electric Sales Corp.

Northlake, Ill.

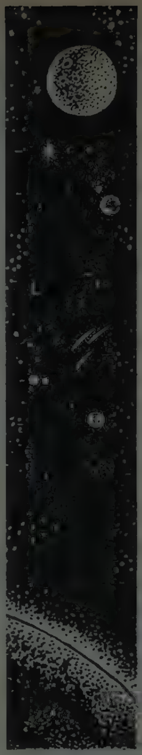
Booths 1906-1908

R. B. Liepold, T. E. Smith, ▲ V. E. James, J. W. Schaffer, ▲ H. P. Hohberger, ▲ A. T. Brennan, R. O. Cuevas, H. A. Grady, G. W. Downs, J. F. Harm, ▲ L. B. Mitchell, D. C. Leis, J. F. Costello, R. Winthrop

Class E Relay with Taper Tab Terminals

Telephone type relays and rotary stepping switches, open or hermetically sealed, for industrial control applications. Also components, sub-assemblies and complete control systems.

(Continued on page 176A)



Here's The Low Cost
ValuMite
Temperature Test Chamber

FEATURING:

- Suitable for Bench Mounting.
- "Off-the-Shelf" Deliveries to You.
- 2 Cubic Ft. Stainless Steel. Test Space.
- Mechanically Refrigerated to −100° F.
- Electrically Heated to +240° F.
- UE Temperature Indicating Controller ± 1° C Temperature Tolerance.
- With Viewing and Utility Ports.
- Plug-In Installation.

IRC INTERNATIONAL RADIANT CORP.
577 E. 156th St., New York 55 N.Y.
CYpress 2-6000
Agents in Principal Cities

HARDWARE
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INSTRUMENTS • AUTOMATION

ONE Source of supply for FASTENINGS

SCREWS
NUTS
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EYELETS
TERMINALS
GROMMETS
ACCESSORIES

We carry in stock thousands of STANDARD and SPECIAL items essential to the INSTRUMENT, ELECTRONIC and AUTOMATION Mfg. industry.

Special Cold Headed Products
Stampings
Screw Machine Parts
Made to order in all metals.

Write for Catalog #60

FEDERAL Screw Products Inc.
3917 N. Kedzie Ave., Chicago 18, Ill.

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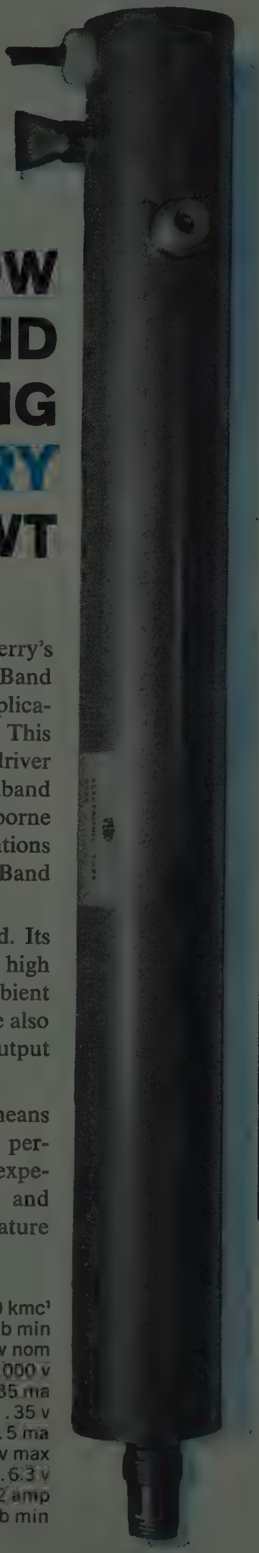
SPERRY MICROWAVE TUBE CLINIC—IRE SHOW

March 21-24, Booths #2432-2438

Bring your problems involving microwave tubes and discuss them with our engineers at this Sperry Clinic.

NOW 60DB GAIN IN L-BAND PPM FOCUSING NEW SPERRY TWT



STL-222

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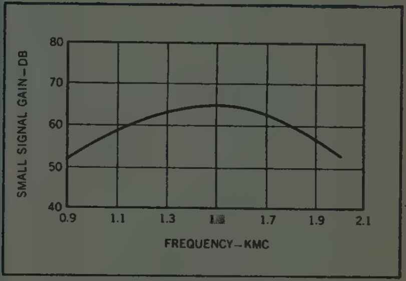
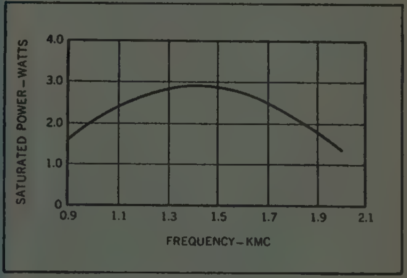
Grid Current	5 ma
Grid Cut-off Signal	−20 v max
Heater Voltage	6.3 v
Heater Current	3.2 amp
Input-Output Isolation	75 db min



Small-Signal Gain vs. Frequency



Saturated Power vs. Frequency

SPERRY

PERRY ELECTRONIC TUBE DIVISION, *SPERRY RAND CORPORATION, GAINESVILLE, FLORIDA*

ddress inquiries: Gainesville, or Sperry Offices in Brooklyn • Boston • Philadelphia • Chicago • Los Angeles • Montreal • Export Dept., Great Neck, N.Y.

Hermetic Seal Corp. Glass-to-Metal and Ceramic-to-Metal Seals for EVERY Electronic Use!

- Crystal Bases
- Vac-Tite Connectors
- Multiple Headers
- Diode Closures
- Transistor Stems
- Single Lead Terminals
- Refrigerant Seals

Hermetic Seal Corporation is your prime source for seals in all sizes, terminations and shapes to fit your specifications. Hermetic is the pioneer in this specialized field and the originator of more than 10,000 different seals. Precision quality-control from design, manufacture and precious metal plating is assured.

SEE US AT THE SHOW
BOOTH #1223

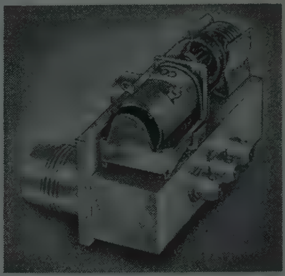
HERMETIC SEAL CORP.
43 River Road, North Arlington, N. J.

Whom and What to See at the Radio Engineering Show

(Continued from page 174A)

Automatic Mfg. Div., Booths 1218–1224
See: General Instrument Corp.

Automatic Metal Products Corp.
315-323 Berry St.
Brooklyn 11, N.Y.
Booth 1524
M. W. Martin, P. Gilbert, X. B. K. Green, E. Bergenfeld, M. Ross, J. Onore, H. A. Feiner, George Smith



*New Compact Coaxial Switch

Coaxial connectors and fittings, subminiature coaxial connectors, microminiature connectors, printed circuit coaxial connectors, coaxial relays and switches, coaxial filters (low, high and band pass, band elimination from 100 to 4000 mc), coaxial cable assemblies, insulated shafts, power plugs, attenuators, directional couplers.

Automatic Seriograph Corp., Booths 1610–1618, 1709–1717
See: Litton Industries, Inc.

Autotronics, Inc.
Box 208
Florissant, Mo.
Booth 1104
▲ E. F. White, ▲ F. Haynes, ▲ A. Lee

Sub-Miniature Clutches & Brakes; Low Voltage D.C. Power Supply Lab. Equipment; *Torque Indicators; *New Pancake Clutch/Brake; Speed Changers; *Flea Power Clutch.

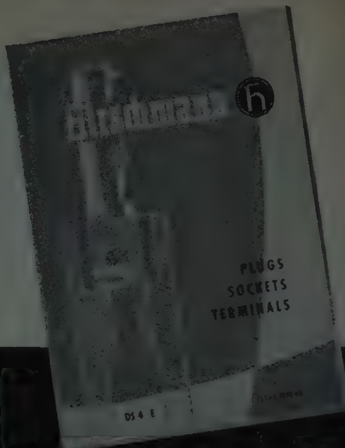
Avco Corporation
Crosley Division
Cincinnati 25, Ohio
Booth 3064
R. E. Stockwell

Scale model of FPS-26 Height Finder Radar system developed by and now in production at Avco/Crosley on a prime contract to USAF.

(Continued on page 178A)

▲ Indicates IRE member.
* Indicates new product.

FREE 52-page catalog



HIRSCHMANN
PLUGS
SOCKETS
TERMINALS
NOW AVAILABLE
ON THE AMERICAN MARKET
Standard of excellence in Europe for more than 30 years. Designed to both American and European standards. Write today Mr. S. M. Scher
RYE SOUND CORP.
145 Elm St., Mamaroneck, N. Y.
West Coast warehouse:
1113 El Centro, Hollywood, Calif.
Other precision Rye Sound products: earphones, headsets, miniature microphones, sub miniature components.

Visit Booth 2933 at the IRE Show

for coupling Magnetron & klystron tuner drives get guaranteed zero back-lash with the

MINI-JOINT*

allowing greater freedom in design!

*Miniature Universal Joints available in single, double & telescoping assemblies with body sizes at: 3/16", 9/32" & 3/8". Bores 3/32" to 1/4" in 1/32" steps. Torque ratings are 16, 64 & 256 oz-in. Write for literature!

FALCON Machine & Tool Co.
208 Concord Tpk., Cambridge, Mass.

BOOTH 4240 IRE SHOW

FEATURES:

- A new low in noise levels — down to 0.007 μv providing 0.02 μv full scale sensitivity at minimum bandwidth.
- 5 db steps
- Attenuation range of 85 db
- FOUR regular VSWR scales plus one expanded
- All meter scales automatically normalized when switching ranges
- Large 5¾″ meter with 1% linearity
- Continuous gain control over 15 db range
- Continuously variable bandwidth control
- Front panel meter monitors bolometer bias current

SPECIFICATIONS:

Frequency: 1,000 cps; adjustable over a 2% range.

Sensitivity: 0.02 μv at minimum (4 cps) bandwidth. 0.1 μv at maximum (40 cps) bandwidth.

Noise Level: 5db below full scale (0.007 μv at minimum bandwidth).

Amplifier Q: 250 at 4 cps; 25 at 40 cps.

Bandwidth: Continuously variable from 4 to 40 cps.

Calibration: Square Law. Meter reads SWR, db.

Range: 85 db. Input attenuator provides 70 db in 5 db steps. Gain control provides 15 db adjustable. Accuracy ±0.1 db per 10 db. Maximum cumulative error of ±0.2 db at 40 cps bandwidth.

Scale Selector: Expanded, Regular, and Bolometer Current. Meter scale always normalized when switching from scale to scale or from expanded to regular.

Meter Scales: SWR: 1-4; SWR: 1.8-6; SWR: 3.2-10; SWR: 6-15; Expanded SWR: 1-1.3; db: 0-10; Expanded db: 0-2.3.

Input Selector: 220,000 ohms; Crystal; Bolometer. Bias provided for high 8.4 ma bolometer or 4.3 ma low current bolometer. Bias adjustable ±15%. A bolometer protective circuit permits any switching operation or cable connect-disconnect without damage to bolometer.

Output: Jack for 1500 ohm recorder, 1 ma full scale deflection.

Input Connector: BNC Jack.

Power: 115/230 v ±10%, 50-60 cps, 40 watts.

Dimensions: Cabinet: 7¾″ wide, 10½″ high, 11″ deep.

Weight: 14 lbs. net.

See the PRD 277-B Standing Wave Amplifier at the I.R.E. Show— Booths 3602-3604-3606.

this standing wave amplifier defies comparison

VOLTAGE STANDING WAVE RATIO
DB
GAIN
BAND WIDTH
INPUT SELECTOR
SWR DB
SCALE
Polytechnic
RESEARCH & DEVELOPMENT
ON

The new portable PRD 277-B Standing Wave Amplifier is designed to meet the present and future needs of microwave test laboratories. Due to its extremely low inherent noise, 0.007 μv, weak signals which once were undetectable by conventional instruments can now be measured. Attenuation in 5 db steps combined with 4 VSWR scales and a large meter permit VSWR measurements to be made with maximum resolution and accuracy.

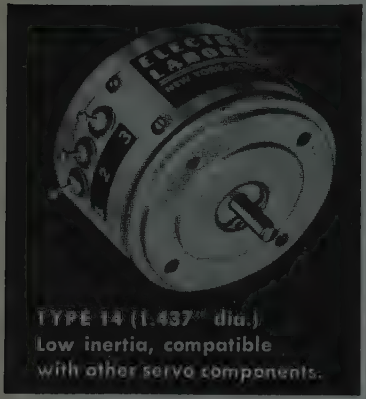
To find out more about the new PRD 277-B Standing Wave Amplifier, contact your local PRD representative or phone, write, or wire:

POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC.

Factory and General Office: 202 Tillary St., Brooklyn 1, N.Y., ULster 2-6800
Western Sales Office: 2639 So. La Cienega Blvd., Los Angeles 34, Calif., UPton 0-1940

Predict performance!
Cut costs!
The key to dependable system performance is

RELIABILITY!



TYPE 14 (1.437" dia.)
Low inertia, compatible with other servo components.

Designers everywhere insist on the rugged reliability of precision potentiometers by Electro-Mec.

- 100% inspection of all vital characteristics.
- Glass insulated terminals.
- 18K gold slip rings.
- Ultra-dependable resistance elements artificially aged to insure stability.
- Exclusive long life wiper design incorporates precious metal contacts.
- Built-in safety factors.

All AIA Sizes .875" to 3.00" Dia.
For complete technical data write to our engineering department.

ELECTRO-MEC
Laboratory, Inc.
47-51 33 Street
Long Island City 1, N. Y.

NEW...
VIBRATING CAPACITOR

A vibrating-reed type capacitance modulator for use in measuring currents as low as 10^{-16} amperes.

Long term stability for process control. Drift ±0.2 millivolts per day, non-cum.

Write for Catalog 523.

STEVENS-ARNOLD
INCORPORATED
7 ELKINS STREET, SOUTH BOSTON 27, MASS.

S/A-12-½-S

Whom and What to See at the Radio Engineering Show

(Continued from page 176A)

Avco Corporation
Research & Advanced
Development Div.
201 Lowell St.
Wilmington, Mass.
Booth 3065

J. E. Wilder, R. C. Amiot, ▲ R. Corrado, ▲ G. Jensen, R. J. Burns, R. P. Conniff, D. G. James, E. D. Kenna, ▲ B. Slavin, ▲ R. D. Grange, R. Mack, N. D. Hudgins

Live Kerr Cell demonstrates sub-millimicrosecond shuttering capability. Plasma Generator spray system for deposition of refractories; Rotating Mirror Cameras. Crosley radar shown.

Avion Division, Booth 1113
See: ACF Electronics Division

Avnet Electronics Corp.
70 State St.
Westbury, L.I., N.Y.
Booth 1103

C. Grey, ▲ R. Hayflick, R. Erhardt, E. Cooney, J. Yonis, J. Nelson, G. Contino, C. Merz, J. Walsh

Automatic Insulation & Circuit Tester

Automatic Insulation and Circuit Tester—Performs automatic production testing of Electrical Components particularly Connectors and Cables for Continuity, Insulation Resistance and High Potential Breakdown—Bendix Connectors, Robertson Splice and Connector Cases, U.S. Semcor Semiconductors—Sangamo Capacitors—Vibrex Fasteners

Axel Brothers, Inc.
Electronics Div.
134-20 Jamaica Ave.
Jamaica 18, N.Y.
Booth 1108

C. Benjamin Axel, R. H. Elkes, M. L. Matnick, C. D. Bitteti, ▲ J. P. O'Donnell, S. Spiegel, S. Zweig, J. Alaimo

Axel Pulse Forming Network

Manufacturers of high-voltage capacitors, low inductance capacitors, pulse forming networks, R. F. suppression filters, special capacitors and related networks.

(Continued on page 182A)

▲ Indicates IRE member.
* Indicates new product.

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

DIRECTIONAL GYRO

This compact new gyro, designed for application in high-performance aircraft and missiles, provides extremely accurate attitude data. Its liquid bubble-type vertical sensing element generates error signals proportional to spin axis displacement from horizontal, while minor wiring modifications permit sensor connection to leveling torquer, completing inner axis leveling loop.

TYPICAL CHARACTERISTICS #A2215

Environmental Capabilities

Vibration:
5g, 20-1000 cps; 10g, 1000-2000 cps
Temperature Range (operative):
—54°C to +71°C
(non-operative):
—65°C to +85°C
Altitude: Unlimited

Azimuth Pickoff

Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor

Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Power: Starting: 35 watts
Running: 7.5 watts

Performance Characteristics

Drift: 4°/hr. max.
Leveling Rate:
Between 2° and 4°/min.
Azimuth Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

Write for complete data.

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

VERTICAL GYRO

Kearfott's rugged new vertical gyro, designed for missile application, is a two-degree-of-freedom instrument with 360° of freedom about inner gimbal axis. Self-contained vertical erection system incorporates liquid bubble-type vertical sensing device.

TYPICAL CHARACTERISTICS #B2115

Environmental Capabilities

Vibration:
5 g, 20-1000 cps;
10 g, 1000-2000 cps
Temperature Range (operative):
—54°C to +71°C
(non-operative):
—65°C to +85°C
Altitude: Unlimited

Pickoffs

Excitation:
26V, 400 cps, single phase
Error from E.Z.: 10 min. max.
Output Voltage (line to line):
11.8V ± 5% max.

Motor

Excitation:
115V, 400 cps, three phase
Power: Starting: 35 watts
Running: 7.5 watts

Performance Characteristics

Repeatability of Established Vertical:
To within a cone of half angle equal to 12 minutes of arc
Scorsby Drift Rate in 5 Min. Time:
0.3°/min. (average)
Erection Rate:
Normal: Between 2° and 4°/min.
Fast: 80°/min. intermittent,
40°/min. continuous

Physical Features

Anisoelastic Drift:
0.08°/min/g^2 at resonance
Weight: 5.5 lbs. (approx.)
Mass Unbalance: 0.1°/min/g

Write for complete data.

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #Q2315

Environmental Capabilities

Temperature Range:
(operative): —54°C to +71°C
(non-operative): —65°C to +85°C
Altitude: Unlimited
Vibration: 10g, 10-2000cps

Pickoffs

Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor

Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Momentum:
2.25 x 10^6 gm cm^2/sec.

Caging and Preset Provision

(Electrically energized torquer type)
Excitation: 115V max./phase
Torquer Constant:
22.8 dyne cm/$Volt^2$

Performance Characteristics

Free Drift:
5°/minute each axis
Runup Time:
1 minute max.
Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

Write for complete data.

Synchronous Motor

Ferrites

Rotary Switch

ROTARY SWITCH

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

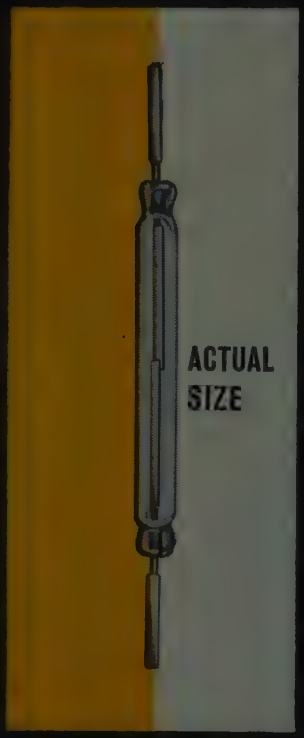
KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

NOW *from C.P. Clare & Co*



Switch capsule of the new Clareed Sealed Contact Reed Relay consists of a pair of magnetically operated contacts, hermetically sealed in a glass capsule, in an atmosphere of inert gas.

SPECIFICATIONS

Contact Arrangement: Normally form A, form B, in combination form C

Overall length: 3-¼ in. max.

Outside diameter: 0.215 in. max.

Contact material: Gold

Contact rating: 15 volt-amperes max., non-inductive: 1 amp. max.; 250 volts max.

Contact resistance: 25-40 milliohms.

Life expectancy: At 14 volt-amperes (½ ampere, 28 volts dc), 20,000,000 operations.
At 7 volt-amperes (¼ ampere, 28 volts dc), 100,000,000 operations.

Minimum breakdown voltage: (60 cps) 500 volts rms.

Insulation resistance: 500 k megohms min.

Low level load test: 8 microamps, 800 ohms, 250 millivolts, open circuit operated at 3 ips, 100 million operations with no failures.

		Milliseconds (including bounce)		
		Operate		
Switches per Coil	Watts to Just Operate Typical Coils	Excess NI over P.U. 100	200	Release
1	0.25	1	0.8	0.25
2	0.30	1.5	0.9	0.25
3	0.35	2.2	1.5	0.25
4	0.42	3.2	2.2	0.25
5	0.52	3.5	2.5	0.25
6	0.8	5	3.5	0.50
12	1.5	6	5	0.50
20	3.5	8	6	0.50

CONTACT BOUNCE	At "just operate"	0.3 ms max.
	At 200 excess NI	0.5 ms max.
	At 400 excess NI	0.8 ms max.
	No bounce on release.	

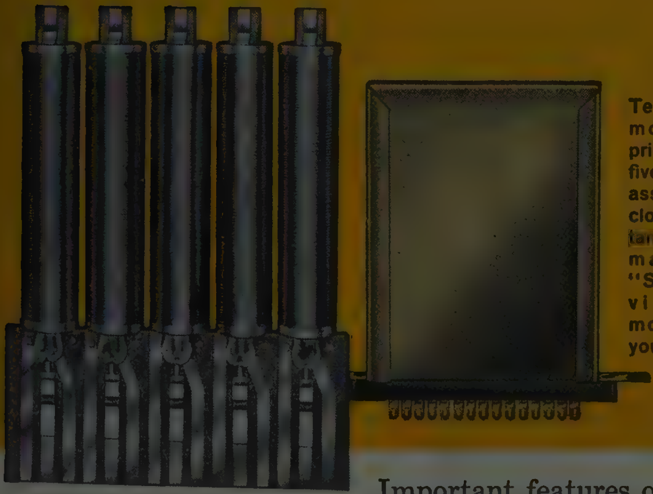
CLAREED®

a New Concept in Relay Design

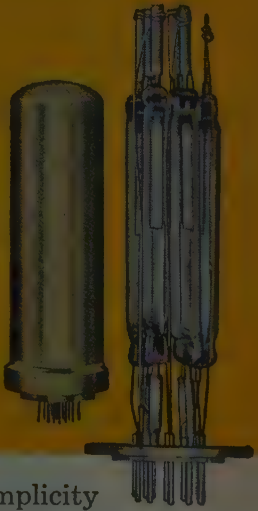
The new CLAREED Sealed Contact Reed Relay effectively eliminates contact contamination. With its contacts hermetically sealed in contaminant-free inert gas, this new design assures millions of perfect operations. Hundreds of millions are possible when operated at up to ½ rated contact load.

CLAREED relays are ideal components for transistor drive applications and for use in computers and data processing equipment. Their low inductance and the low inductance change in the operating coil at each operation limits the transients produced. Submit your packaging problem for recommendations.

• PACKAGED TO MEET *your* REQUIREMENTS



Ten CLAREED switches, mounted in line on a printed circuit board with five magnetic coils. This assembly can then be enclosed in the flat, rectangular container or it may be coated with "Skin-Pack," a tough vinyl plastic, and mounted directly into your equipment.



Six CLAREED switches clustered for mounting in a single tube container.

Important features of CLAREED relays are their simplicity and flexibility. They may be mounted to meet the requirements of almost any application and environmental condition, even on your own printed circuit board—to comply with your mechanical design configurations.

CLAREED relays are as flexible as your application requires. Consultation with your nearby CLARE sales engineer is invited. Additional information may be obtained from C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC 5.*

SEE IT AT THE IRE SHOW

New York Coliseum
March 21-24

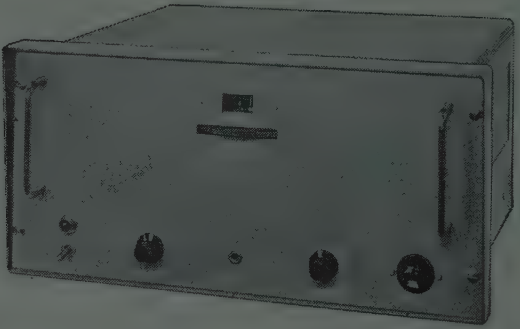
BOOTH NOS. 2218 & 2220

CLARE

FIRST
in the industrial field

NEW Powertron
AC ELECTRONIC GENERATOR

MODEL 150
$525⁰⁰



PRECISION
AC POWER
SUPPLY FOR
LABORATORY &
PRODUCTION USE

SPECIFICATIONS
Power Output .... 160 V.A.
Fixed Frequency 400 CPS (other freq. avail.)
Variable Frequency .... 350-450 CPS
External Frequency .... 50-4000 CPS
Total Distortion .... Less than 1%
Regulation .... Less than 1%
Operates with load of any power factor
Small size .... 8¾" x 19" Panel

Also Available — Model 250 — 250 VA Power Output

Representatives in Principal Cities

ITECO INDUSTRIAL TEST EQUIPMENT CO.
55 EAST 11th STREET • NEW YORK 3, N. Y.
VISIT BOOTH #3513, IRE SHOW, NEW YORK COLISEUM

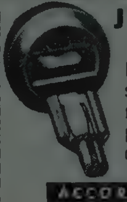
For the highest
RELIABILITY
IN PRECISION
COMPONENTS

specify
FAIRCHILD
GYROS
PRESSURE
TRANSDUCERS
ACCELEROMETERS
POTENTIOMETERS

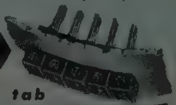
FAIRCHILD
CONTROLS CORPORATION
COMPONENTS DIVISION
225 Park Avenue, Hicksville, L. I., N. Y. • 6111 E. Washington Blvd. Los Angeles, Cal.
A Subsidiary of Fairchild Camera and Instrument Corporation

Heyco Nylon BUSHINGS

STRAIN RELIEFS
The insulating bushing that anchors a cord set to an electrically operated machine or appliance.



JUNCTION-TERMINAL BUSHINGS
Eliminate "pig-tails" — Miniature size. Snap-in assembly, color or number coded. Can be used as plug-in receptacle. Simple quick disconnect.



ACCORDIAN TYPE
Fit curved surfaces
Nylon bushing — brass tab

HEYCO NYLON Snap Bushings
10 Sizes for holes from ⅜" to 1¾" dia. — various inside diameters. Snap locks into panels up to ⅜" thick.

FREE SAMPLES! BUSHINGS OF YOUR CHOICE

HEYMAN
MANUFACTURING COMPANY
KENILWORTH 7, NEW JERSEY

Whom and What to See at the Radio Engineering Show

(Continued from page 178A)

B & F Instruments, Inc., Booth 3123
3644 N. Lawrence St.
Philadelphia 40, Pa.

▲ Eugene Frank, Robert G. Ball, ▲ C. E. Stufflebeam, Jack Morrison, Al Shore, Gerrie Kingan

Data Acquisition Systems (Strain Gage, Transducers & Temperature Plotting & Logging); Transducer Signal Input Conditioning Equipment (Bridge-Balance & Calibrating Units, *Power Supplies, and *Amplifiers) Miniature and *Sub-Miniature; Transducers (Torquometers, Accelerometers & Force Gages) Custom Measurement & Control Systems.

Babcock Relays, Inc., Booth M-15
1640 Monrovia Ave.
Costa Mesa, Calif.

Carl L. Martin, Wilhelm F. Juptner, Ed Landa, John Hunter, Nate Salsbury, Abe Siegal

Several series of miniature and subminiature relays of highest order accuracy and reliability, including BR1S, BR3, BR7 and BR8 for airborne and ground applications involving high G load, extreme shock and vibration.

Baird-Atomic, Inc.
33 University Rd.
Cambridge 38, Mass.
Booths 3219-3221

▲ Eugene Cronin, ▲ Sy Futran, ▲ Walter Driscoll, Paul Watson, Clarence B. Whims, Jr., ▲ Carl Richardson, ▲ Sam Kenton, Charles B. Russell

Baird-Atomic, Inc. will exhibit a complete line of Transistor Test instrumentation. The following B/A Models will be featured: Portable Beta Tester; GP-4, 1 meg; KP-2, 1 amp 100v; KP-2H 2 amps 200v; MW-1 Curve Tracer 50 amps continuous; NA-1 Component Selector—checks 50 transistors at a time; 4 pt. probe and Minority Carrier Life-time Tester. Special Counting, Trigger and Readout Tubes will also be displayed.

Baker & Adamson, Booth 4216
See: Allied Chemical Corp.

Baker Contact Division, Booths 2110-2118
See: Engelhard Industries, Inc.

Baker Platinum Division, Booths 2110-2118
See: Engelhard Industries, Inc.

Balco Research Laboratories, Inc., Booth 2431
49-53 Edison Place
Newark 2, N.J.

▲ M. K. Goldstein, Hans Goetting, V. Caruso

Metallized * teflon and foil teflon high temperature (to 250° C)—hi performance capacitors with sub miniature types—excellent for transistor applications; also hi performance foil and metallized mylar & polystyrene types. Hermetically sealed, epoxy and other casing arrangements available. Voltage ranges from 15 volts up, capacity ranges .0001 to 50 MFD, tolerances to 1%.

(Continued on page 184A)

▲ Indicates IRE member.
* Indicates new product.

Elevators at north
and east sides
of the main lobby
take you direct to the
Fourth Floor

Oscilloscope operates from
Internal battery
External DC
and AC line
TYPE 321 OSCILLOSCOPE

Using a Type 321 to check the omni-directional navigation aid feature of an aircraft tranceiver.

TRULY PORTABLE

Battery Powered.
Weighs only 13½ lbs. without batteries.
Batteries weigh 2 to 4 lbs.
Size only 5¾" x 8¾" x 16".

HIGH PERFORMANCE

Vertical Response: DC to 5 MC, 0.07 μsec risetime.
Calibrated Sensitivity: 0.01 v/div to 20 v/div in 11 calibrated steps. Continuously adjustable from 0.01 v/div to 50 v/div.
Calibrated Sweeps: 0.5 μsec/div to 0.5 sec/div in 19 calibrated steps. Accurate 5x magnifier extends calibrated range to 0.1 μsec/div. Continuously adjustable from 0.1 μsec/div to 1 sec/div.
Simplified Triggering: Fully automatic, or amplitude-level selection with preset stability control.
4-KV Accelerating Potential on 3" crt.
6-div by 10-div Display Area. (¼" div.)
Amplitude Calibrator.

NO POWER SOURCE PROBLEMS

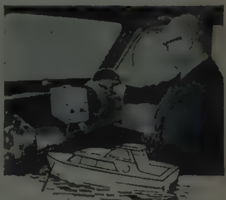
Operates from:

1. Ten size D Flashlight cells, ½ hour continuous, more with intermittent, operation.
2. Ten rechargeable cells, 4.3AH—5 hours continuous operation.
3. 11.5 to 35 v dc (aircraft, auto, boat, etc.)
4. 105 to 125 v ac or 210 to 250 v ac, 50 to 800 cps.

Price	**$775.00**
Built-in Battery Charger	**35.00**
Complete Set of 4.3AH Batteries	**66.00**

f.o.b. factory.

NEW TRANSISTORIZED PORTABLE OSCILLOSCOPE



It's so easy to take the Type 321 wherever an oscilloscope is useful. It's a convenient solution to many difficult situations, too ... for example: Where power cords are apt to be a nuisance—where isolation from ground is desirable—where power-line fluctuations are troublesome—where hum pick-up is a problem. The Type 321 is sure to satisfy your portable oscilloscope needs.

Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon
Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albuquerque, N. Mex. • Atlanta, Ga. • Baltimore (Towson, Md.) • Boston (Lexington, Mass.) • Buffalo, N.Y. • Chicago (Park Ridge, Ill.) • Cleveland, Ohio • Dallas, Texas • Dayton, Ohio • Denver, Colo. • Detroit (Lathrup Village, Mich.) • Endicott (Endwell, N.Y.) • Greensboro, N.C. • Houston, Texas • Kansas City (Mission, Kan.) • East Los Angeles, Calif. • West Los Angeles, Calif. • Minneapolis, Minn. • New York City Area (Albertson, L.I., N.Y. • Stamford, Conn. • Union, N.J.) • Orlando, Fla. • Philadelphia, Pa. • Phoenix, (Scottsdale, Ariz.) • San Diego, Calif. • San Francisco (Palo Alto, Calif.) • St. Petersburg, Fla. • Syracuse, N.Y. • Toronto (Willowdale, Ont.) Canada • Washington, D.C. (Annandale, Va.)

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

SEE THE NEW TEKTRONIX KMC OSCILLOSCOPE AT THE IRE SHOW—BOOTHS 3027-3030

Whom and What to See at the Radio Engineering Show

(Continued from page 182A)

Ballantine Laboratories, Inc.

102 Fanny Rd.
Boonton, N.J.
Booths 3402-3404

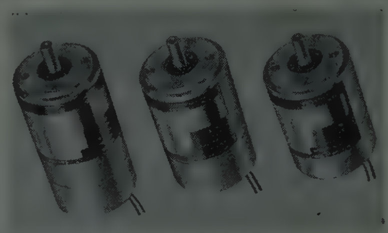
▲ A. W. Parkes, Jr., ▲ Frank R. Zayac, ▲ Henry Kruger, Herbert Vorwerk, Edward Cahalan, ▲ Dr. Endel Uiga, ▲ Wallace F. White, ▲ Gustav Manik, ▲ Uwe Beckmann

Sensitive Electronic Voltmeters; True RMS Voltmeter; Very Low Frequency Voltmeter; AC-DC Precision Calibrator; Decade Amplifier; Sensitive Electronic Inverter; Electronic Capacitance Meter; Linear AC-DC Converter.

Barber-Colman Co.

Electrical Components Div.
1800 Rock St.
Rockford, Ill.
Booth 2244

W. F. Tice, R. A. Knowles, W. F. Falk, J. H. Goethel, R. Sandak, S. D. Reed



Precision 1¼″ Permanent Magnet D-C Motors

Permanent Magnet & Split Series D-C Motors, 400 Cycle A-C Motors, D-C Tachometer Generators, Gearheads, Ultra-Sensitive Polarized D-C Relays. See Complete Line of 1¼″ Diameter Permanent Magnet Motors In Three Frame Lengths With Constant Brush Pressure, Very Low Ripple.

Barber-Colman Co.

Small Motors Div.
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F. D. Utter, B. L. Hitt, P. H. Werner, R. Shepard

Low-cost Servo Motor and A-C Tachometer Generator

A-C Shaded Pole Induction Motors, Unidirectional, Reversible, Synchronous Types, Available With Gearheads. Fans & Blowers for Cooling Electronic Equipment. See Demonstrations of Tachometer Generator and Electronic Servo Control. Ideal for Servo-Mechanisms, Remote Switching and Positioning Devices, And Recording Instruments.

Barnes Engineering Co.

30 Commerce Road
Stamford, Conn.
Booth 3036

Paul Bernard, John J. Horan, Stephen N. Bobo, Robert S. Schenck

Infrared and Electro-optical Components, Instruments & Systems. Precision Infrared Sources, Detectors & Radiometers. Instruments for monitoring, analysis & control of industrial temperatures. Systems for search, detection, tracking & imaging of aircraft and missiles. Meteorological radiometers. Satellite instrumentation; horizon sensors.

(Continued on page 186A)

Where can I find it?

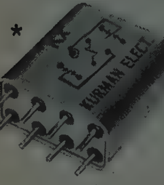
IRE MEMBERSHIP. The IRE membership booths at the Waldorf-Astoria Hotel and the Coliseum main lobby can provide you with information and application blanks for IRE membership and professional group membership. Also available here are membership cards and pins, IRE publications, and order blanks for the "Convention Record" which gives the complete text of all papers presented at the convention.

CAFETERIA. Second mezzanine at south side of floor. Take elevator 16.

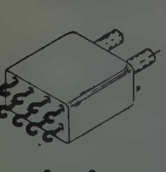
FIRST AID ROOM. First mezzanine at north side of floor. Take elevator 20.

LIST OF REGISTRANTS. A complete list of all persons who have registered, brought up to date twice daily, is on the first mezzanine at the back of the first floor.

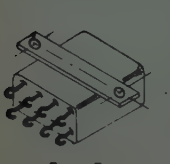
Another KURMAN First! A COMPLETE LINE OF MICRO-MINIATURE RELAYS "OFF-THE-SHELF"



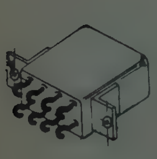
Case 0



Case C



Case D



Case E

COMPETITIVELY PRICED

. . . available in prototype or production quantities from your nearby sales agency. Will fill most of your applications saving you time and money.

*SERIES KXI MICRO-MINIATURE

(.40 Max. x .875 x .80 Max.)

Equipped with special DPDT 2 amp contacts rated to carry any load from dry circuit to full rating. Features at 1/10″ grid spaced header. Nominal operating power—250 milliwatts.

New torsional rotation balanced armature offers 20G 2,000 cycle vibration and 50G shock immunity. Proven reliability under all environmental conditions.

PLACE YOUR ORDER TODAY

RELAY NO.	CASE STYLE	HEADER	CONT. ARR.	CONTACT RATING (AMPS)	6, 12, 24 VDC Net (Quant. 1-10)÷
KX1P20	0	Plug-in	DPDT	2 amp	$15.95
KX1H2D	D	Solder	DPDT	2 amp	16.20
KX1H2C	C	Solder	DPDT	2 amp	16.20
KX1H2E	E	Solder	DPDT	2 amp	16.20

÷ For Discounts on larger quantities see Kurman Sales Agency or write to factory.

These leading Distributors — Kurman SALES AGENCIES — stock our complete line

EAST
Almo Radio Co., Philadelphia
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Mace Electronics, Erie, Pa.
Milo Electronics Corp., New York
Quad Electronics, Inc., Brooklyn
Radio Equipment Corp., Buffalo
Schenectady Electronic Dist. Corp., Schenectady
Stack Electronics, Inc., Binghamton
Terminal Radio Corp., New York
Valley Electronic Labs, Inc., Utica
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SOUTHEAST
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Glenn Allen Co., Inc., Memphis, Tenn.
Goddard Distributors, W. Palm Beach

MIDWEST
Industrial Electronic Supply of Grand Rapids, Grand Rapids
Interstate Supply Co., St. Louis
Pioneer Electronic Supply Co., Cleveland

MIDWEST (Cont.)
Radio Parts Co., Milwaukee
Relay Sales, West Chicago
Sun Radio Co., Akron
United Radio, Inc., Cincinnati

SOUTHWEST
Busacker Electronic Equipment, Houston
Central Electronics, Dallas
Lavender Radio Supply Co., Inc. Tyler, Tex.
Lenert Co., Houston
Midland Specialty Co., El Paso, Texas
Trice Wholesale Electronics, Oklahoma City

WEST
Avionic Supply, Culver City, California
Ballard Supply Co., Ogden
C & G Radio Supply, Seattle, Centralia, Tacoma, Bremerton, Olympia, Aberdeen
Dean Electronics, Long Beach, Calif
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See our catalog pages in the new Radio-Electronic MASTER

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Subsidiary of Crescent Petroleum Corp. • Quality Relays Since 1928
191 Newel St., Brooklyn 22, N. Y.
Export: 135 Liberty St., N.Y.C. Cable: TRILRUSH

Way out ahead...

with Connectors at Factory Prices and Prompt Delivery

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UG CONNECTORS, MS CONNECTORS
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Progress Electronics maintains the most complete "ready-to-ship" stock of UG connectors, MS connectors and coaxial cables. You get factory price *plus* immediate delivery! Progress is the authorized distributor for many of the country's leading manufacturers of connectors. Call or write for technical data, prices and literature.

For fastest out-of-town service, call our ENterprise numbers or use our TWX Number — New York 1-1377.

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You are cordially invited
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The St. Moritz Hotel
March 21-24

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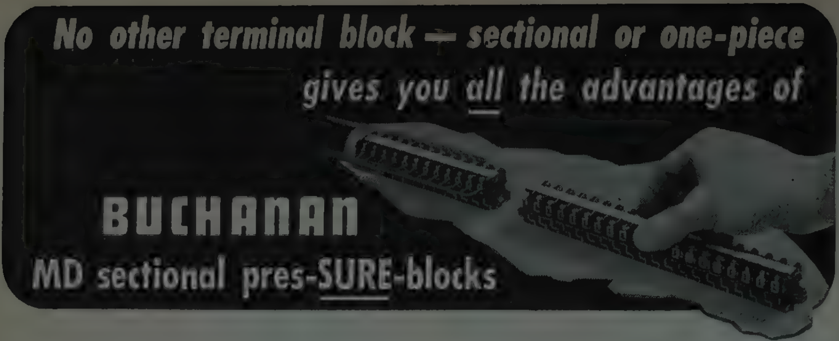

No other terminal block — sectional or one-piece
gives you all the advantages of
BUCHANAN
MD sectional pres-SURE-blocks

NO WASTE CIRCUITS—Reduce material costs, save space. Supplied assembled in 20 snap-fit section lengths. Pull off or add groups for any length block.

SMALLER INVENTORY—Only 2 different parts (contact and end sections). No running out of needed items.

MORE CIRCUITS IN AVAILABLE SPACE—Increase contact capacity, decrease jumpering. Group common wires (equivalent to 1 #22 thru 1 #8) in tubular contacts. Contacts on 7/16" centers. 10 circuits 4 7/16", plus 21/32" for each complete block.

NO TERMINALS OR LUGS—Eliminate lugging costs. Tubular contacts provide secure, efficient connections.

NO HIDDEN CIRCUIT MARKINGS—Unobscured top marking area minimizes errors. Integral or separable strips.

QUICKER TO INSTALL AND CHANGE—Hand assembled, no fixtures or hardware. Mount only every 12 sections. Add circuits without removing mounting screws.

LOW INSTALLED COST—Competitive with conventional blocks of similar rating.

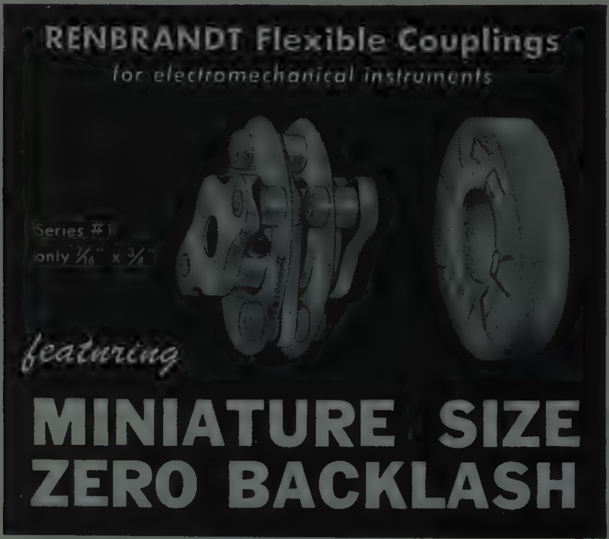
Separate Sections or Factory-Assembled Blocks
Flat Base or Channel Mounting • Tubular or Strap-Screw Contacts
Fanning Strips • Conservative 750-volt A.I.E.E. rating

Tubular contacts fully approved by U.L. Blocks fully approved for 600 V by C.S.A.

Write for Bulletin R-3

Booth 2341
I. R. E. Show
New York–Mar. 21-24

BUCHANAN
ELECTRICAL PRODUCTS CORPORATION
HILLSIDE, NEW JERSEY



You can save space and weight by using Renbrandt Flexible Couplings. They have torsional rigidity, angular and linear flexibility, low inertia and yet are *entirely free of backlash.* The unique disc-type design assures long life at a moderate price. Available for 1/16" through 1/2" shafts in all combinations. Many hub styles including clamp, set screw.

Prompt delivery on prototype or production orders. Send for catalog or send your requirements for quotes.

Tinymite Flexible Coupling

Low cost. Thousands of uses for manual controls, tuners, plug-in units, sub-miniaturization, etc. Size 1/2" dia. by 21/32" long. No backlash. Insulating nylon center piece.

Renbrandt

Renbrandt, Inc.
6-K Parmelee St.
Boston 18, Mass.
tel: Highlands 5-8910

See Booth M-6, the IRE Show

Whom and What to See at the Radio Engineering Show

(Continued from page 184A)

Barnstead Still & Sterilizer Co.

2 Lanesville Ter.
Boston 31, Mass.
Booth 4004

A. M. Fulton, D. G. Miller, S. Atkins, V. C. Smith, N. A. Everett, B. M. Greely, E. Morgan

Barnstead Transistor Washer

Transistor Washers, Cooling Water Repurification Systems for high purity water, *BD-10 disposable-cartridge demineralizers with 1200 GPH flow rate, stills and small demineralizers, extremely fine water and air filters, conductivity meters that give readings to 18 megohms resistance up to 212°F.

Barry Controls Incorporated, Booth 2534

700 Pleasant St.
Watertown 72, Mass.

M. Lazarus, T. P. Goethel, T. Stewart, H. Bostder, T. Black, S. Cluett, J. Ruzicka, H. Perley

Damped Structures* are New Techniques in Methods of Reducing Resonant Response to Reduce Structural Fatigue, Component Failures. Varipulse 16750*—A New Shock Testing Machine for Laboratory and Production Testing of Small Components Such As Relays.

Basic Products Corp., Booths 2815-2819

See: Sola Electric Co.

Beattie-Coleman, Inc., Booth 3823

1000 N. Olive St.
Anaheim, Calif.

J. A. Wilcox, J. B. Olsson, R. Baxter, Jr., P. Hammond, J. S. Beattie, R. Winkler

Oscilloscope cameras, electrically pulsed automatic still data recording cameras and punched Mylar tape programmers.

Beckman Instruments, Inc.
Berkeley Division
2200 Wright Ave.
Richmond, Calif.
Booths 3416-3418

Robert Ward, John Scheck, Edward Buchs, Dick Swift, Dick Major

Digital test and control equipment including: *EPUT meters and timers with in-line, in-plane presentation. *Fully transistorized EPUT and Preset EPUT Meters. *High frequency meters reading up to 12,000 Mc in direct digital form. *High speed digital recorder. *Special digital building block display featuring methods of obtaining direct readings of flow, pressure, temperature, force and speed.

Beckman Instruments, Inc., Helipot Div. & Shockley Transistor Corp., Booths 1201-1205

See: Helipot Div. & Shockley Transistor Corp.

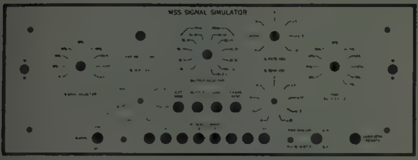
▲ Indicates IRE member.

* Indicates new product.

Whom and What to See at the Radio Engineering Show

Beemer Engineering Co.
401 N. Broad St.
Philadelphia 8, Pa.
Booth 4522

A. J. Diesinger, Jr., H. G. Silcox III, W. A. Strauss, Jr., K. H. Kuhlen, G. B. Schoeps, H. D. Shields, H. H. Clarke, D. H. Talbott, Jr., D. R. Blair, R. H. Talbot, G. H. Bierman, Robert Herzog



MSS Signal Simulator

Oilite Products of Powder Metallurgy; Parco O-Rings and Molded Rubber Parts, Teflon by Halogen; Aeroduct Ventilating Ducting; Photo-Etched Panels and Precision Contact Blanks and Parts.

Behlman Engineering Co., Booth 2709
2911 Winona Ave.
Burbank, Calif.

Jean Schroeder, ▲ Edward Bertolet, Gene Cahn, Bob Schermerhorn, Bill Friedman, Claire Cahn

Invertron, a completely electronic ac power source—fixed or variable frequencies—single or multiphase output configurations—power ratings to 5kva single phase—10 kva two phase—15 kva three phase—other specifications on special order.

Belden Manufacturing Co., Booths 4217-4219
415 S. Kilpatrick Ave.
Chicago 44, Ill.

▲ Ray Reading, ▲ Frank Timmons, Warren Stuart, John McEwen, E. V. Blake, Al Kayworth, George Kyros, Ed Stull

Wiremaker for Industry. One wire source for everything electrical and electronic. Custom engineered and designed electronic wires and control cables, coax cables, MIL spec wires, hook-up wires, silicone lead wires, magnet wires, portable cordage and cord sets.

Bell Aircraft Corp.
Avionics Division
P.O. Box 1
Buffalo 5, N.Y.
Booths 3822-3824

Thomas J. Trimbach, Donald A. Rosenfield, Laurier A. Wood, James F. Downing, Joe Sherman, ▲ William B. Howells

BELL Aircraft CORP.

Inertial guidance and navigation systems and components, all-weather automatic landing system, control and recovery systems for missiles and drones, beacon systems, surveillance and countermeasures systems.

(Continued on page 188A)

▲ Indicates IRE member.
* Indicates new product.

Display your badge or pocket card with your name very prominently. Even your competitors will welcome you. Every visitor is important to every exhibitor. Help him to know who you are so he can serve you better. By reading your badge he can more swiftly estimate what will interest you and show it to you.

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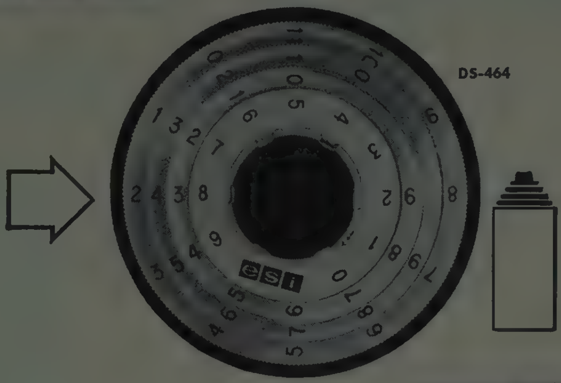
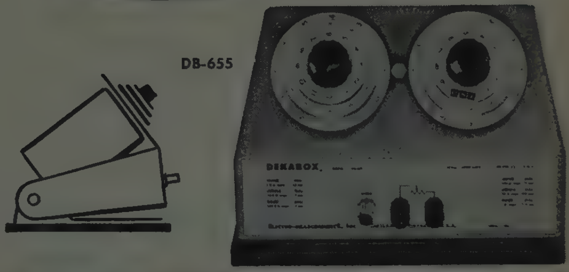
esi DECADE RESISTORS


DS-464


DB-655

RS-624

MODEL DS SERIES DEKASTAT®—Precision decade resistors for panel mounting, featuring the exclusive ESI DEKADIAL® concentric dial assembly for convenient straight line readings. Total resistance values available from 1,200 to 120,000 ohms with accuracy of ±0.05%. Power rating, ½ watt per step. 3 or 4 decades of resolution. *Standard units available from stock. Prices: $63.00 to $110.00.*

MODEL DB SERIES DEKABOX®—Precision decade resistors similar to Model DS series DEKASTAT® units, but conveniently mounted on an adjustable base with binding posts. Features ESI DEKADIAL® design for straight line readings. Total resistance values available from 12,000 ohms to 1.2 megohms with accuracy of ±0.05%. 3 to 6 decades of resolution. Power rating, ½ watt per step. *Standard units available from stock. Price: $73.00 to $151.00.*

MODEL RS SERIES DEKASTAT®—Rack-mounted precision decade resistors. Adjusted to very close tolerances for use as laboratory resistance standards. Independently operated dials provide both coarse initial steps for quickly approximating the required value and progressively finer steps for more exact settings. Less than 10 ppm/C° temperature coefficient. Total resistance values to 1.2 megohms. Accuracy, 0.02%. Six decades of resolution. Power rating, ½ watt per step. *30-day delivery: Price: $550.00.*

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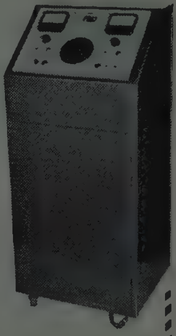
Standard Power Supplies and Transformers are available from stock. Others can be built to your specific requirements from stock components.

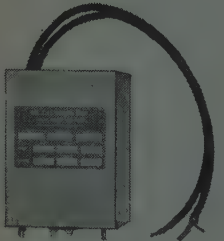
HIGH VOLTAGE POWER SUPPLY
MODEL 120-5-2

- 120 KV D.C. at 5 MA
- Zero Start
- Completely Instrumented
- Reversible Polarity
- Input 115V-60 cycle
- Safety Interlock
- No exposed high voltage components
- Many Other Features



MODEL
120-5-2

Completely instrumented supplies are available from 30 KV to 300 KV D.C. and up to 50 KVA.



COMPACT HIGH VOLTAGE POWER SUPPLIES

- Selenium Rectifiers
- Low Ripple
- Reversible Polarity
- Shielded Output Cables
- Hermetically Sealed Can
- Epoxy Filled
- INPUT: 115 Volts—60 to 400 Cycles

Model No.	*Output*	*Dimensions* W D H
2.5-2-1	2.5KV-2MA	3 x 2½ x 4½
5-2-1	5KV-2MA	3 x 3½ x 4½
10-1-1	10KV-1.25MA	3 x 3½ x 5½
15-1-1	15KV-1.25MA	4¼ x 5⅛ x 6¾
20-1-1	20KV-1.25MA	4¼ x 5⅛ x 6¾
25-1-2	25KV-1.25MA	4¾ x 6 x 7¼
30-1-2	30KV-1.25MA	5 x 6½ x 7¾

For additional information write to Department IR.

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Whom and What to See at the Radio Engineering Show

(Continued from page 187A)

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Enfield, Middlesex, England
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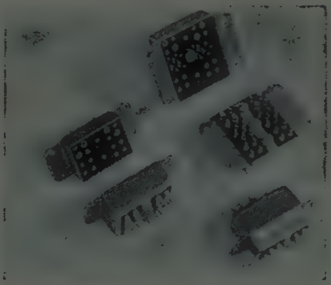
C. H. Frank, D. M. Harris, John Bailey, George Rose, M. Kandell, H. Rothman



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See: M. C. Jones Electronics Co., Inc.

Bendix Aviation Corp., Montrose Division, Booths 2222-2232, 2329-2331
South Montrose, Pa.

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(Continued on page 190A)

▲ Indicates IRE member.
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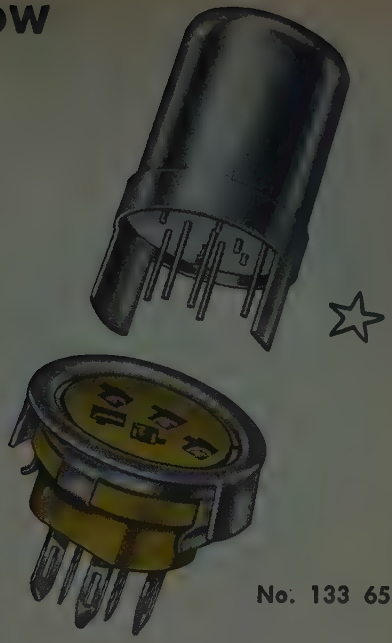
CINCH SOCKET FOR THE RCA NUVISTOR TUBE



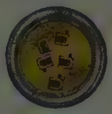
No. 133 65 10 001

Low insertion force and contact protection . . . require minimum space . . . fullfilling every requirement for miniaturized equipment

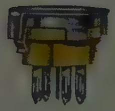
The socket provides two slots o different widths mating with twc corresponding legs depending from the metal envelope o the tube to index the tube and socket contacts. As a resul the tube can be inserted by feel only and it is impossible tc insert the tube incorrectly or damage the contacts. The socket saddle provides spring elements that engage with the depending legs of the tube envelope thus grounding the envelope to the panel.

The socket body is of low loss phenolic insulation, Type MFE The saddle is of cold rolled steel, cadmium plated. The contacts are of copper alloy with cadmium plating.

Although the contact tails are of sub-miniature size, an ample slot is provided for ease of soldering connecting leads.



No. 133 65 10 001



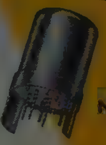
ELECTRICAL RATINGS:

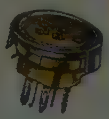
	VOLTS AC RMS	VOLTS DC
LTAGE BREAKDOWN:		
level (adj. terminals)	1600	2600
level (to ground)	1800	3000
itude 3.4 in. hg. (adj. terminals) 50,000 ft.	500	800
itude 3.4 in. hg. (to ground)	600	900
LTAGE RATINGS:		
l level (adj. terminals)	550	850
level (to ground)	600	1000
itude 3.4 in. hg. (adj. terminals) 50,000 ft.	160	250
itude 3.4 in. hg. (to ground)	200	300
COMMENDED WITHSTANDING VOLTAGE:		
l level (adj. terminals)	1200	1500
level (to ground)	1300	1600
itude 3.4 in. hg. (adj. terminals) 50,000 ft.	350	600
itude 3.4 in. hg. (to ground)	450	700

rrent Rating:	1 ampere
ntact Resistance:	0.05 ohms Maximum
ulation Resistance:	50,000 Megohms Minimum
pacitance: tween one contact and all other nducting parts.	.25 mmf Maximum

ctrical tests performed in accordance with EIA ndard RS-167.

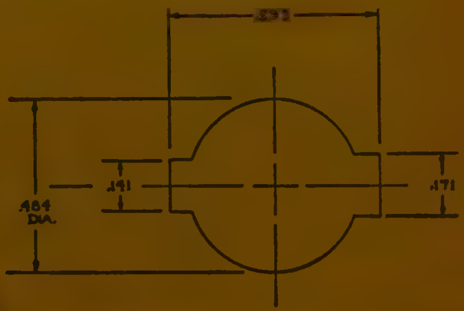
ACTUAL SIZE





RCA NUVISTOR TUBE

The socket fits into a .484 diameter hole with two slots as shown below, and the two legs of the socket that fit into these slots fold over on the under side of the panel, this holds the socket securely in place.



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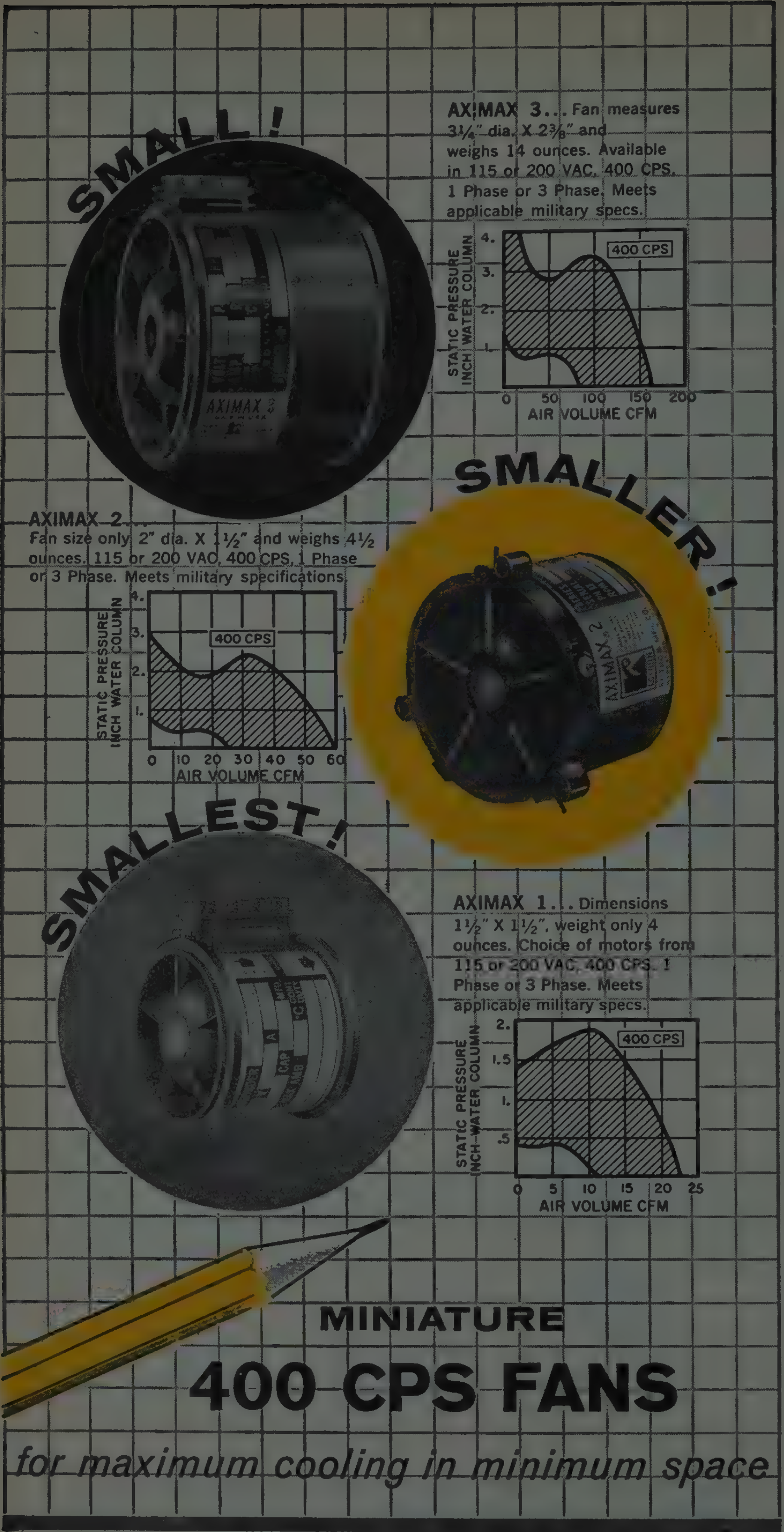
Division of United-Carr Fastener Corporation, Boston, Mass.



AXIMAX 3 . . . Fan measures $3\frac{1}{4}$" dia. X $2\frac{3}{8}$" and weighs 14 ounces. Available in 115 or 200 VAC, 400 CPS, 1 Phase or 3 Phase. Meets applicable military specs.

AXIMAX 2 . . . Fan size only 2" dia. X $1\frac{1}{2}$" and weighs $4\frac{1}{2}$ ounces. 115 or 200 VAC, 400 CPS, 1 Phase or 3 Phase. Meets military specifications.

AXIMAX 1 . . . Dimensions $1\frac{1}{2}$" X $1\frac{1}{2}$", weight only 4 ounces. Choice of motors from 115 or 200 VAC, 400 CPS. 1 Phase or 3 Phase. Meets applicable military specs.

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400 CPS FANS

for maximum cooling in minimum space

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Whom and What to See at the Radio Engineering Show

(Continued from page 188A)

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Red Bank Div.
Electron Tube Section
Eatontown, N.J.
Booths 2222-2232, 2329-2331

Daniel J. Bell, Donald B. Blanchard, ▲ Joseph F. Bozzelli, James M. Degnan, Rudolph K. Forsman, Thomas B. MacCullough, John H. Moor, R. A. Soerhoff, ▲ Eugene W. Swenarton

ELECTRON TUBES: Special Purpose tubes—receiving and transmitting; Gas tubes—Noise Sources, spark gaps (both trigger and protective types), Zenon Thyratron, Voltage regulators, time totalizers; Microwave tubes—Backward Wave Oscillators, klystrons, traveling wave tubes, metal ceramic (external anode).

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Semiconductor Products Section
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▲ R. R. Meijer, B. L. Gilluly, R. C. Lancaster, B. D. Gentry, D. I. Snell, ▲ H. Newman, ▲ E. Belmont

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Benrus Watch Co., Booth 1625
See: Pic Design Corp.

Bergen Laboratories, Inc., Booth 2840
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Paterson 1, N.J.

▲ Max Hoberman, ▲ Tom Bright, ▲ Fred Seekamp, ▲ Walter Katz

Chronistor elapsed time indicator for military and commercial use. G-fuse shock and impact indicator. Driver for silicon controlled rectifiers* for control of large amounts of power from small signals. Electrocap* system of electronic corrosion control.

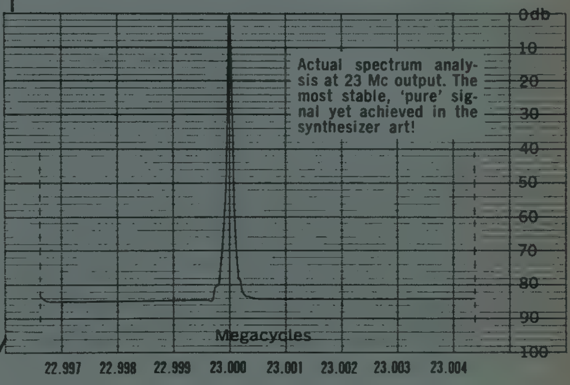
(Continued on page 195A)

AT MANSON . . . STATE-OF-THE-ART TECHNOLOGY IS A CONTINUAL ACHIEVEMENT!

A prime example is the MODEL N317 CRYSTAL FREQUENCY SYNTHESIZER . . . known to the military as the 0-464 Oscillator . . . which generates over *66,000* discrete sinusoidal frequencies — each stable to 1 x 10^{-8} per day!

Replacing bank upon bank of precision crystal oscillators, the N317 Synthesizer reduces packaging space to *less than 1.1 cubic feet.* Exact, infallible selection — and *re-selection* — of any of its frequencies is made in a matter of seconds.

MODEL N317 Crystal Frequency Synthesizer



Actual spectrum analysis at 23 Mc output. The most stable, 'pure' signal yet achieved in the synthesizer art!

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  250 cps from 4-8 Mc
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  1000 cps from 16-34 Mc
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- **100 MILLIWATTS MINIMUM OUTPUT** across 50 ohms
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MODEL RD-140A
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$395.00

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Ultra-Accurate
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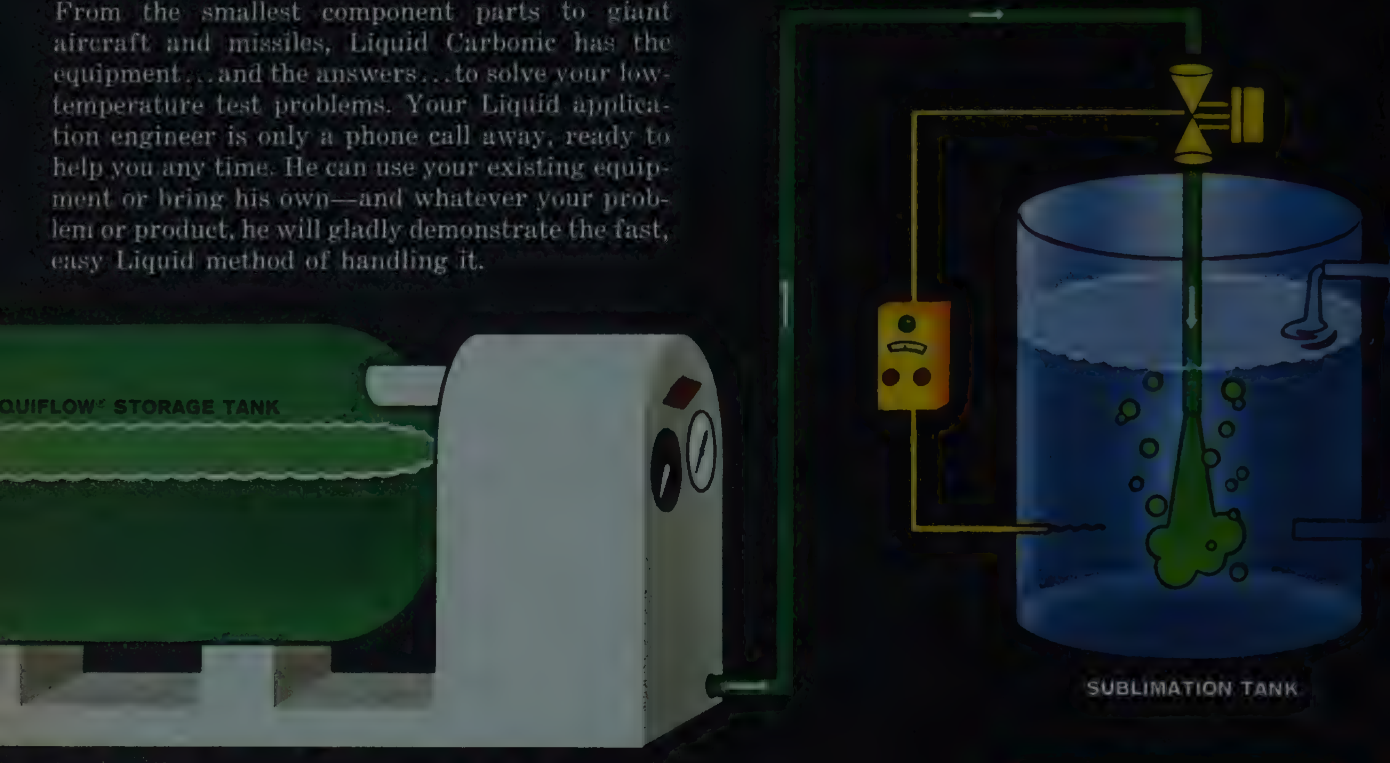

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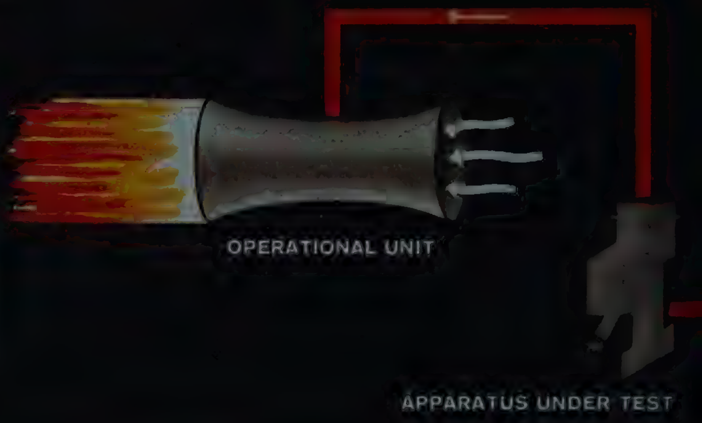
Ideal for fuel, vacuum, hydraulic fluid or altitude testing. This unique indirect system can be adapted to existing overloaded mechanical systems, and is suitable for cooling jet engine fuels or for such human factor testing as space suits. Here's the fast, easy way to make environmental low-temperature tests—resulting in better, more dependable products. For top performance wherever normal atmospheres must be maintained, Liquid's indirect solvent system is the answer.



MULTIPLY YOUR ENGINEERING MANPOWER!

If your mechanical refrigeration unit is taking 8-10 hours to pull down from 200° F. to —65° F., CO_2 will do the same job in 8-10 minutes! Liquid's direct CO_2 injection pulldown to mechanical hold actually increases productive engineering time. Here is the ideal unit for your "fast-drop" tests to save both time and money.

Ask your Liquid Carbonic application engineer how *you* can save with a fast, improvised test on *your* product! Contact him today for a demonstration with this portable CO_2 testing equipment right in your own plant or laboratory at no obligation.

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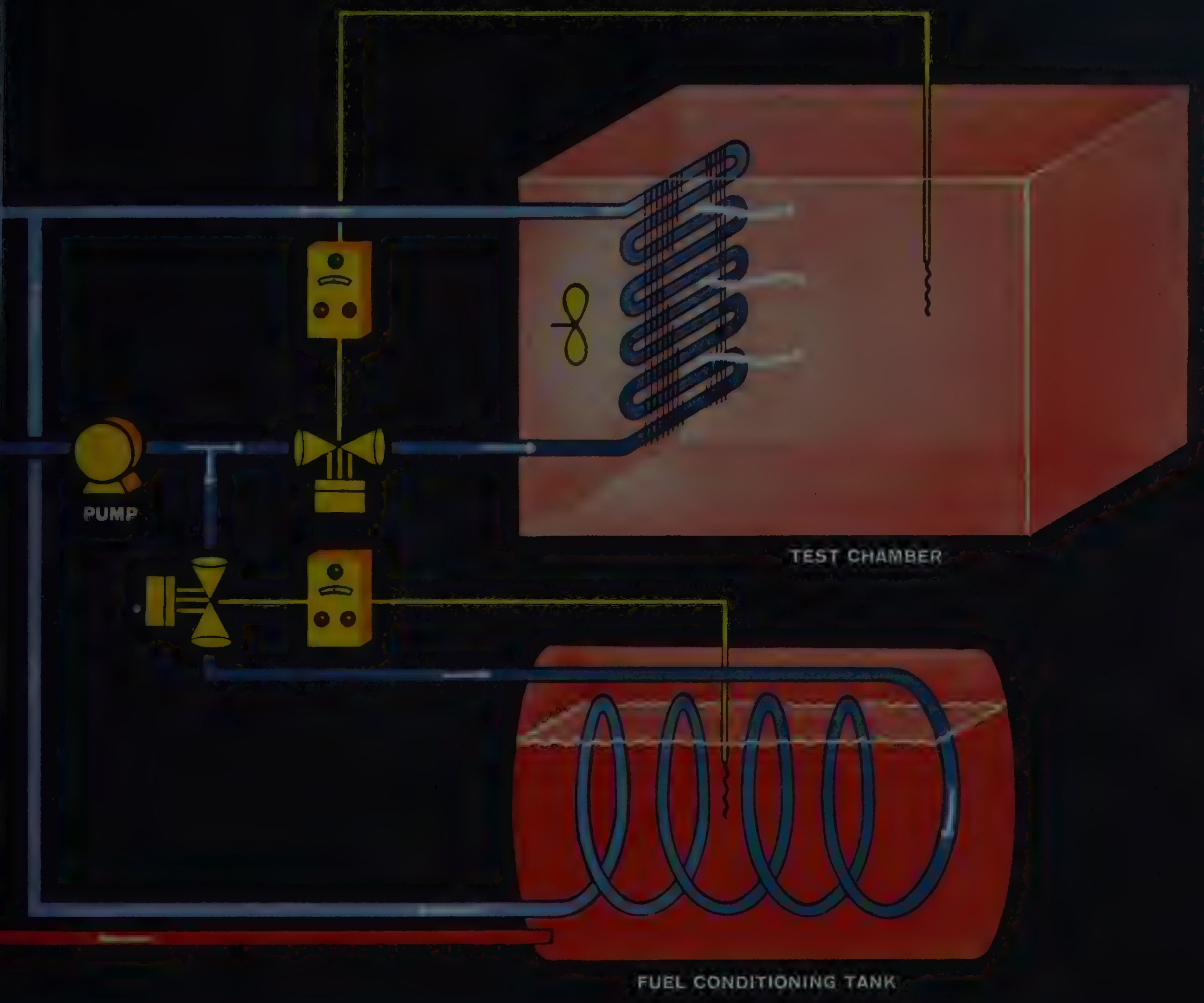
A Major Producer of Compressed Gases, Oxygen, Acetylene, Nitrogen,

environmental testing with CO_2



DIRECT INJECTION

You can have unlimited refrigeration capacity with only a temperature controller and valve, chamber, and low-cost CO_2. In fact, for one ton of refrigeration per hour, you need only approximately one pound of CO_2 per minute! This handy unit is inexpensive and easy to operate, gives immediate pulldown to −109° F., and lends itself to simple automation.

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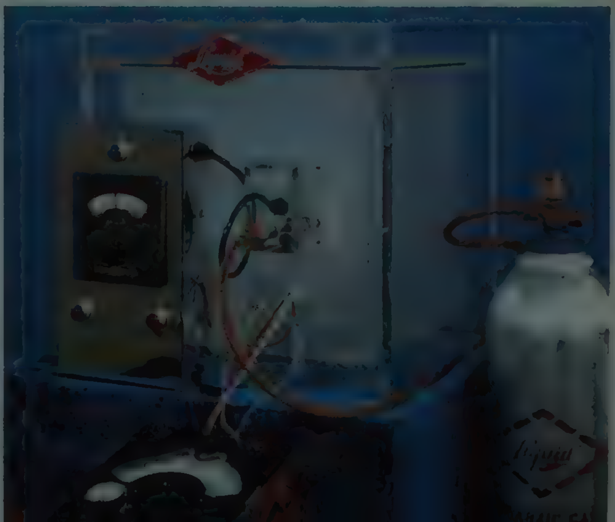
GD CORPORATION | L-C DIVISION

Liquid Carbonic Division
135 South LaSalle Street
Chicago 3, Illinois

In Canada:



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manufacturers of a complete variety of standard microwave test equipment and components,

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which include the following:

- adapters
- test horns
- attenuators
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- twists
- signal samplers
- crystal detector mounts
- terminations
- loads
- phase shifters
- slotted lines
- switches
- tees
- transitions
- tuners
- wave meters

These units will be supplied in the following EIA designated tubing sizes: WR77, WR975, WR1150, WR1500, WR1800, WR2100, WR2300.

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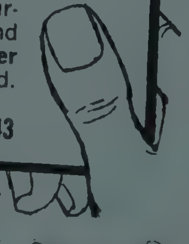

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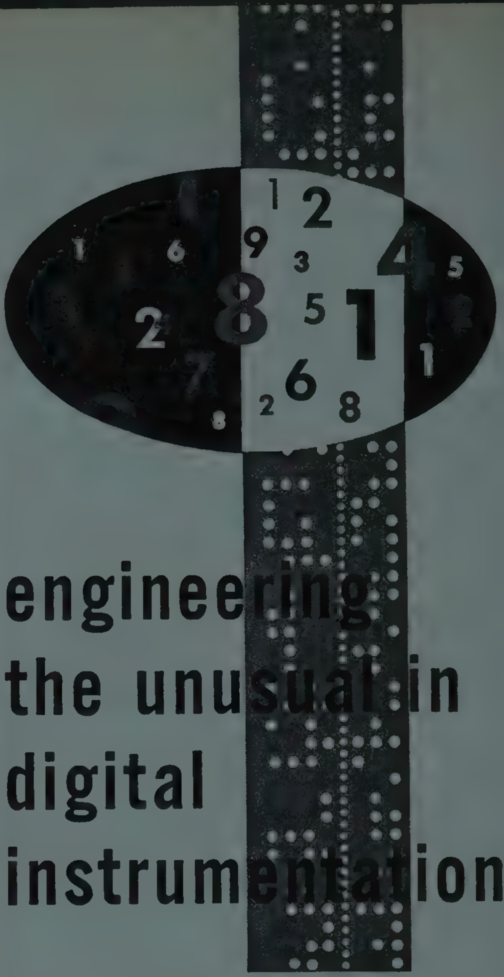

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SEE THE NEW
MODEL 500A Digital Multimeter,
MODEL 201A Digital Voltmeter,
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COMMUNICATIONS AND CONTROL DIVISION
VAN NUYS, CALIFORNIA

Whom and What to See at the Radio Engineering Show

(Continued from page 190A)

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M. Birnbach

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George Wright, ▲ J. M. Wolfskill, R. T. Schlaudecker, W. S. Riblet, H. A. Yocum

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Angelo Lazzara, Philip Lazzara, ▲ Joseph A. Lawler, Frank Marsillo, William F. Wilde, Claude A. Gates, Richard Gates

*POWER-O-MATIC 60 Saturable Power Reactor Control & Range-Lock Protection Mechanical Convection Ovens. POWER-O-MATIC 60 has no moving parts, no electronic amplifiers, tubes, no mercury or mechanical relays or switches—also MAGNI-WHIRL water and oil baths, VAPOR-TEMP Controlled Humidity Chamber & Muffle Furnaces.

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John F. Bodnar

Plastic Panels, Dials, Knobs MIL-P-7788. Electronic Telegraph Equipment.

(Continued on page 196A)

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see all four floors!

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Whom and What to See at the Radio Engineering Show

(Continued from page 195A)

Boesch Mfg. Co., Inc.
45 River St.
Danbury, Conn.
Booth 4202

▲ Arthur H. Boesch, ▲ Francis D. Schatzle, Henry Walendzik, William W. Clarke, Arthur Melillo, Leon Yarrish, Kenneth Murch

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Bogart Manufacturing Corp., Booth 2339
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P. O. Box 500
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Bogue Electric Mfg. Co., Booths 2115-2117
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Paterson 3, N.J.

Joseph Rambusek, Mike Scholnick, Haskell Medalie, Donald Lind, Harry Skerrett, George Greer, Frank Jarmuz

Rectifiers, Power Supplies.

Bomac Laboratories, Inc.
Div. of Varian Associates
Salem Rd.
Beverly, Mass.
Booths 2710-2712

Cyrys Haller, James F. Dean, ▲ Robert W. Andrews, ▲ Bayard Robbs, Williard S. Ferris, C. Peter Roberts, Earl D. Benson

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Microwave Tubes and Components.

(Continued on page 198A)

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* Indicates new product.

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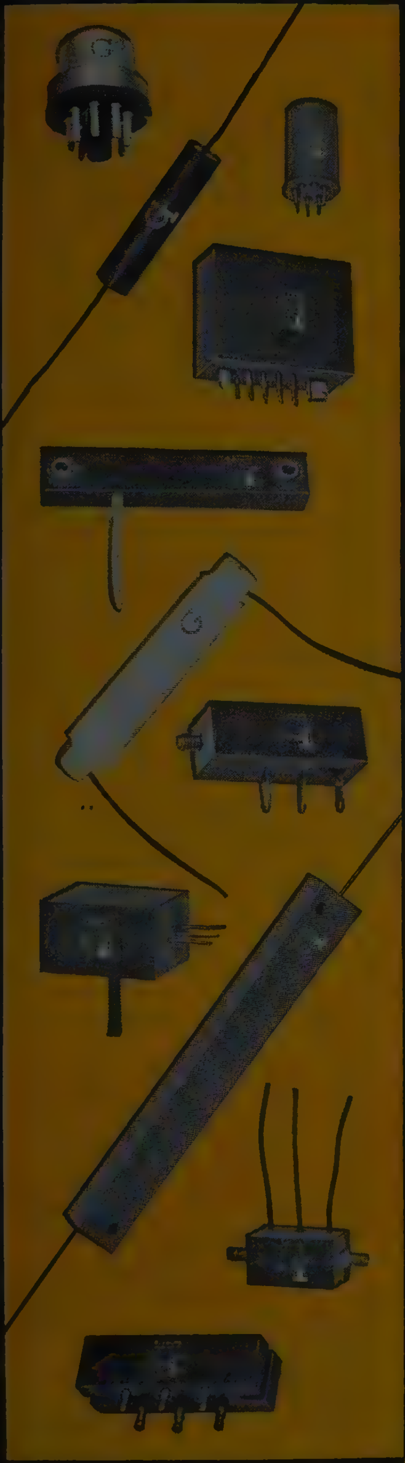

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Whom and What to See at the Radio Engineering Show

(Continued from page 196A)

Boonton Electronics Corp.
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Booths 3101-3102

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Booths 2505-2507

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See: Pesco Products Division.

Boston Division, Booth 2208
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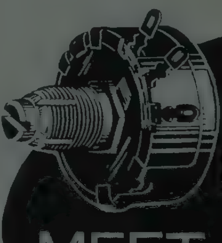
(Continued on page 202A)



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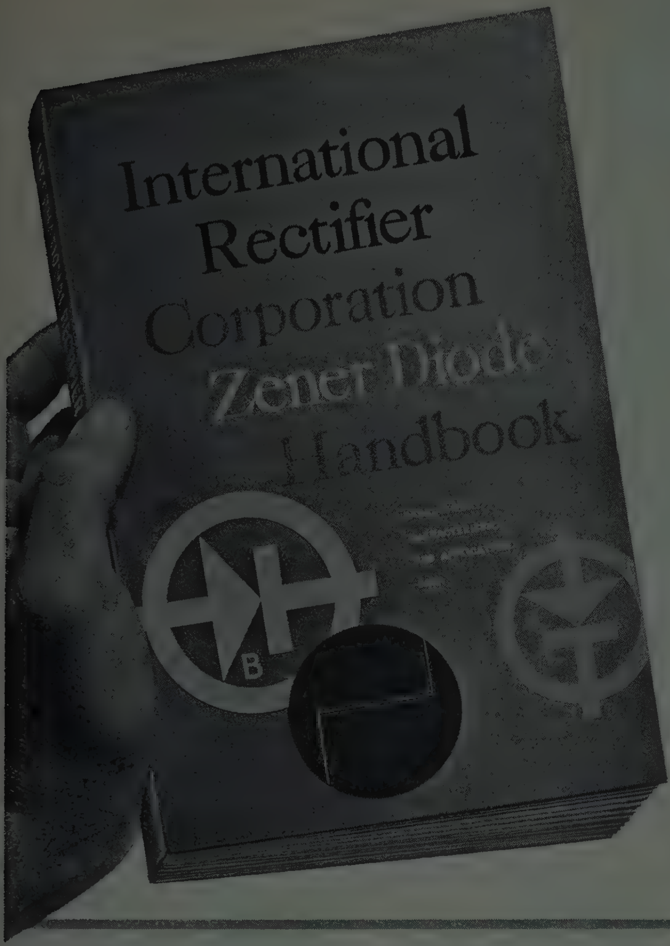

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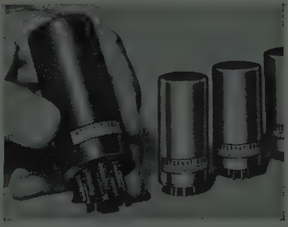
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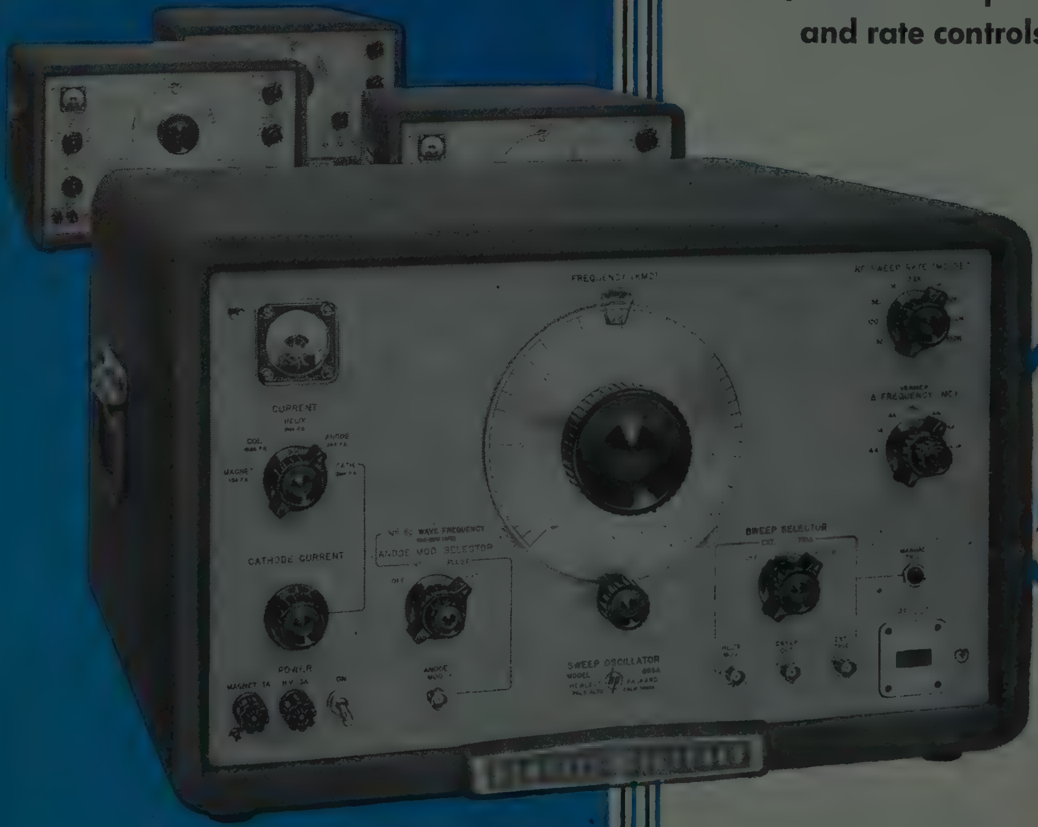
4 new microwave sweep oscillators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◀ Figure 1. Arrangement for high speed microwave measurement to provide rapid visual display with hp 130A/B oscilloscope.

hp Dependable, quality

Hewlett-Packard Electronic Sweep Oscillators are new measuring tools deliberately designed to give you simpler, faster microwave measurements. Four models are provided, covering frequencies 2.0 to 18.0 KMC as follows: Model 683A, 2.0 to 4.0 KMC; Model 684B, 4.0 to 8.1 KMC; Model 686A, 8.2 to 12.4 KMC and Model 687A, 12.4 to 18.0 KMC.

These instruments make possible microwave investigations and evaluations with a convenience previously associated only with lower frequency measurements. These oscillators provide a wide range of sweep speeds so that measurements of reflection, attenuation, gain etc., can be displayed on an oscilloscope or recorded in permanent form on X-Y or strip-chart recorders.

Electronic Sweeping

Specifically, the new oscillators provide either a CW or swept rf output throughout their individual bands. The instruments employ new backward wave oscillator tubes whose frequency is shifted by varying an applied potential. Thus, troublesome mechanical stops and tuning plungers are eliminated. Sweep range is continuously adjustable and independently variable; sweep rate is selected separately, and either can be changed without interrupting operation. The full band width can be covered in time segments ranging from 140 seconds (very slow for mechanical recorder operation) to 0.014 seconds (high speed for clear, non-flickering oscilloscope presentation).

Linear Frequency Change

The swept rf output from the -hp- sweep oscillator is linear with time, and a linear sawtooth voltage is provided concurrent with each rf sweep to supply a linear time base for an oscilloscope or recorder. In addition, for convenience in recording and other operations, rf sweeps can be triggered electrically externally and single sweeps can be triggered by a front panel push button. The rf output can also be internally AM'd from 400 to 1,200 cps and externally AM'd or FM'd over a wide range of frequencies.

Rapid Visual Presentation

The variety of sweep rates and band widths available from the new oscillators insures convenience and accuracy for reflection and transmission coefficient measurements and many other production line and laboratory tests. For maximum speed, an oscilloscope such as -hp- 130A/B may be used as indicated in the diagram on opposite page. For maximum information and a permanent record, an X-Y or strip chart recorder may be used.

Complete details of a rapid visual method using an oscilloscope or a maximum-data, permanent record method using a recorder may be obtained from your -hp- field engineer. Detailed discussions of these methods are also contained in the -hp- Journal, Vol. 8, No. 6, and Vol. 9, No. 1-2, available on request.

TYPICAL SPECIFICATIONS

Below are specifications for -hp- 686A Sweep Oscillator, 8.2 to 12.4 KMC. Specifications for -hp- 683A, 684B, and 687A (P band) are similar except for frequency range and other minor variations.

Types of Outputs: Swept Frequency, CW, FM, AM.

Single Frequency Operation

Frequency: Continuously adjustable 8.2 to 12.4 KMC.

Power Output: At least 10 milliwatts into matched waveguide load. Continuously adjustable to zero.

Swept Frequency Operation

Sweep: Recurrent; externally triggered; also manually triggered single sweep. Rf sweep linear with time.

Power Output: At least 10 MW into matched waveguide load. Output variation less than 3 db over any 250 MC range; less than 6 db over entire 8.2-12.4 KMC range.

Sweep Range: Adjustable in 7 steps 4.4 MC to 4.4 KMC.

Sweep Rate-of-Change: Decade steps from 32 MC/sec. to 320 KMC/sec.

Sweep Time: Determined by sweep range and rate; from 0.014 to 140 seconds over full-band.

Sweep Output: +20 to +30-volt-peak sawtooth provided at a front-panel connector concurrent with each rf sweep.

Modulation

Internal Amplitude: Square wave modulation continuously adjustable from 400 to 1200 cps; peak rf output power equals cw level ± 1 db.

External Amplitude: Direct coupled to 300 KC; 20 volt swing reduces rf output level from rated cw output to zero.

External Pulse: +10 volts or more, 5 millisecond maximum duration.

External FM: Approx. 350 v peak to modulate full frequency range.

General

Input Connectors, Impedances: BNC; above 100,000 ohms.

Output Connector: Waveguide cover flange (686A, 687A); Type N, female (683A, 684B).

Power Requirements: 115/230 volts ±10%, 50/60 cps; approximately 540 watts.

Price:
-hp- 683A (2.0 to 4.0 KMC) $3,000.00.
-hp- 684B (4.0 to 8.1 KMC) $2,900.00.
-hp- 686A (8.20 to 12.40 KMC) $2,900.00.
-hp- 687A (12.40 to 18.00 KMC) $3,400.00.

(Prices above are f.o.b. factory for cabinet models. Rack mount instruments $15.00 less.)

Data subject to change without notice.

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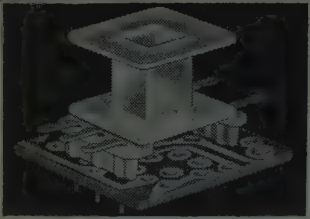
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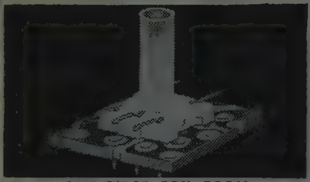
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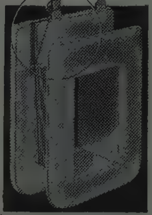
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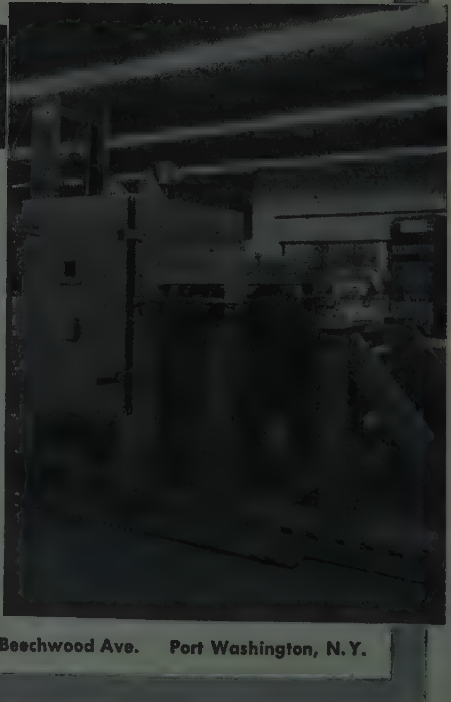

Components and assemblies can be vibrated in altitude chamber or free air, both horizontal or vertical, up or down. Chamber Range: 0 to 200,000 ft. at −120°F. to +600°F.

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Whom and What to See at the Radio Engineering Show

(Continued from page 198A)

William Brand—Rex Division, American Enka Corporation, Booths 4306-4310
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Concord, Mass.

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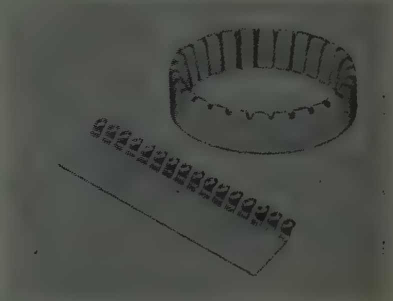

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(Continued on page 204A)

ABSOLUTE MAXIMUM RATINGS AT 25°C

Forward Current	I_f	50 mA
Minimum Breakover Voltage	V_{bo}	TSW-30 30V TSW-60 60V
Reverse Breakdown Voltage	V_r	TSW-30 30V TSW-60 60V
Storage Temperature		−65°C to 150°C
Ambient Temperature Range		−55°C to +125°C

SPECIFICATIONS AND TYPICAL CHARACTERISTICS

(At 25°C Unless Otherwise Stated)

		Typical	Max.	Test Conditions	
Saturation Voltage	V_s	1.0	1.5	Volts	$I_c = 50$ mA
Forward Leakage Current	I_F	0.1	10	μA	$V_c = 30V$
Reverse Leakage Current	I_R	0.1	10	μA	$V_c = -30V$
Forward Leakage Current	I_F	20.	50.	μA	at 125°C
Reverse Leakage Current	I_R	20	50.	μA	at 125°C
Gate Voltage to Switch "ON"	V_g On	0.7	1.0	Volts	$R_L = 1K$
Gate Current to Switch "ON"	I_g On	0.1	1.0	mA	$R_L = 1K$
Gate Voltage to Switch "OFF"	V_g Off	1.2	4.0	Volts	$I_c = 50$ mA
Gate Current to Switch "OFF"	I_g Off	7.0	10.	mA	$I_c = 50$ mA
Holding Current	I_H	2.0	5.0	mA	$R_L = 1K$

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- Ring Counters
- Shift Registers
- Controlled Rectifier Driver
- Flip-Flop Equivalent
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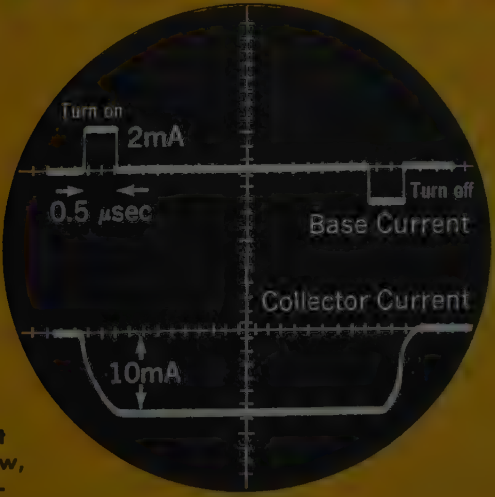
announces a NEW computer element for: Greater Reliability. Circuit Simplicity

THE TRANSWITCH



Be sure
o visit
Transitron at
the IRE Show,
New York—
Booths 1319-1323

The TRANSWITCH is a new bistable silicon device that can be TURNED OFF with gate current.

This PNPN latching device "remembers" its last gate signal. High current gain, both turn-on and turn-off, leads to greater circuit simplicity and inherent reliability. Excellent linearity of electrical parameters over a wide current range fulfills both low logic level and medium power needs.

Here is a unique device that replaces TWO transistors plus resistors in most bistable circuits and permits increased component density.

Furthermore, the transwitch is FAST . . . requiring only 0.3 microseconds to turn ON or OFF!

The TRANSWITCH is now available from TRANSITRON in the popular JEDEC TO-5 package, ready to solve your switch-on-switch-off requirements.

For further information, write for Bulletin TE-1357A

Transitron
electronic corporation • wakefield, massachusetts

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This newly developed Floating Zone Scanner is a product of Lindberg's technical staff, widely recognized for many significant developments in the application of heat to industry. Expertly designed, it provides more accurate and more precise production of semi-conductors as well as serving as ideal research equipment. Already, a number of important companies in the semi-conductor field are using this equipment for research and production. Lindberg Induction Heating Units have been specifically designed for use as research and production equipment for crystal growing and zone refining of semi-conductors and other materials. Write for our Bulletin No. 1600.

Look in at Lindberg Booth M-9 at the New York Show

High Frequency Division
LINDBERG ENGINEERING COMPANY
2482 WEST HUBBARD STREET, CHICAGO 12, ILLINOIS
Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California
In Canada: Birlefco—Lindberg, Ltd., Toronto

LINDBERG heat for industry

Whom and What to See at the Radio Engineering Show

(Continued from page 202A)

British Radio Electronics Ltd., Booth 1820
1833 Jefferson Place, N.W.
Washington 6, D.C.

▲ F. D. Harris, J. H. Barclay, W. P. Dean, P. O. Harris

Precision Linear & Sine/Cosine Potentiometers; Silvered Mica Capacitors; Miniature Air Dielectric Temperature Compensating Capacitors; Sub Miniature Deposited Carbon Resistors; Switches and Transformers; Slow Motion Tuning Dials.

Brubaker Electronics, Booth 2128
See: Telecomputing Corp.

Brush Instruments Div., Booths 2616-2626
See: Clevite Corp.

Buchanan Electrical Prods. Corp.
225 U.S. Route 22
Hillside, N.J.
Booth 2341

James O. Johnson, Albert C. Schultz, Kenneth W. Todd, Paul E. Vance, William J. Waldron, Charles F. Walker

Buchanan Pre-Insulated Splice Cap

*New Pre-Insulated Splice Caps for solderless pigtail splicing, installed with fast-acting production line hand and pneumatic tools featuring exclusive three-indent rolling action crimp, Solderless wire terminals and connectors. Modular and unit terminal blocks, also fanning strips.

Buckbee Mears Co.
Toni Bldg., 4th & Rosabel Sts.
St. Paul 1, Minn.
Booth 4506

Norman C. Mears, Harvey T. Holsapple, A. W. Amundson

Electroformed mesh and evaporation masks for electron tubes and subminiature transistor manufacturing, etched metal and glass precision parts for special projects or mass produced component parts, precision printed circuits, micro mesh sieves for submicron particle size determination.

Budd Company, Booths 4224-4226
See: Continental-Diamond Fibre Corp.

Budd-Stanley Co., Inc., Booth 1810
43-01 22nd St.
Long Island City 1, N.Y.

▲ Jules Simmonds, ▲ William Quinn, Budd Meyers, Stanley Gartman, Paul Sherman

Custom microwave products manufactured to specification—featuring pattern tested antenna feeds, rotary joints, antenna feed systems, duplex-mixers, hybrid junctions, attenuators and transmission pieces from 1,000 mcs. to 26,500 mcs. All fabricated of aluminum, magnesium or brass.

▲ Indicates IRE member.
* Indicates new product.

Whom and What to See at the Radio Engineering Show

Bulova Watch Company, Electronics Division, Booths 1719-1721
40-01 61st Street
Woodside 77, New York

J. T. Stokes, J. Harlan, F. Cheli, M. Bloch, ▲ A. Strauss, H. Buckman, A. Matistic, E. Walsh

Frequency control systems and components, crystal ovens, servo amplifiers, crystal filters and package oscillators. Complete frequency control from 30 cps to 100 mc, stabilities to 1PP 10^9.

Burgess Battery Co., Div. Servel, Inc., Booth 2806
Foot of Exchange St.
Freeport, Ill.

W. F. Gallagher, Calvin Broughton

Complete line of Dry Batteries, Mercury Activators, Water Batteries, Sealed Nickel Cadmium Batteries.

Burlingame Associates
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Mount Vernon, N.Y.
Booths 3814-3816

▲ Harold A. Bogin, ▲ Roland Reisley, ▲ Gerry Sullivan, ▲ Arnold Ackerman, ▲ Don Anderson, ▲ Al Beckman, ▲ Don Carter, ▲ Bob Crane, ▲ Bernie Greenberg, ▲ Harold Kurland, ▲ Al Lee, ▲ Marty Maloy, ▲ Jim Randall, ▲ Joe Giguere, ▲ Clark Smoll, ▲ John Takakjian, ▲ Dick Bullock, ▲ Jim Bogin

Coordinated Test Equipment Display—Also New instruments for: precise generation of AC and DC Power, Voltage; Accurate AC and DC Voltage measurement and calibration.

Burndy Corp., Omaton Div.
Norwalk, Conn.
Booths 1329-1331

S. Bergmau, A. Aune, L. Gage, E. Valenrach, R. Smith, A. Behnke, S. Schulman, W. Bonwitt, H. Dupre, M. Lazar, D. Dibner, F. March, L. Gray, L. Berkley, S. Cotro, P. Putignano, M. Potenza, R. Atkinson, E. Garwett, R. Resker, E. Salz, G. Woeth, P. Costello, J. Costello, P. Carwithen, M. Elkind, J. Bertram, M. Gordon, P. Williams, F. Desmond, W. Gregory, G. Turrian

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(Continued on page 206A)

▲ Indicates IRE member.
* Indicates new product.

First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

For basic research, pilot plant studies and the more efficient production of semi-conductors—new Lindberg Diffusion Furnaces

Here is a new Lindberg Furnace designed specifically for basic research, pilot plant work, or production of solid state devices. It is offered in a variety of sizes and capacities to enable industries in the semi-conductor field to have higher powered equipment adequately insulated and designed for its specific use. With this type of furnace available, it is not necessary for industry to attempt to adapt ordinary furnaces to the highly specialized requirements of the semi-conductor field. For complete information on Lindberg's standard line of furnaces specifically designed for gaseous and solid diffusion uses write for our Bulletin No. T-1081.

Look in at Lindberg Booth M-9 at the New York Show

Pilot Plant Equipment Division
LINDBERG ENGINEERING COMPANY
2482 WEST HUBBARD STREET, CHICAGO 12, ILLINOIS
Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California
In Canada: Birlefco—Lindberg, Ltd., Toronto

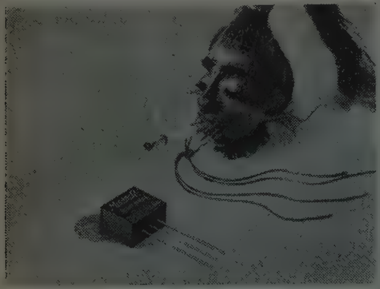
LINDBERG heat for industry

Whom and What to See at the Radio Engineering Show

(Continued from page 205A)

Burnell & Co. Inc.
10 Pelham Pkwy.
Pelham Manor, N.Y.
Booths 2909-2910

▲ L. G. Burnell, ▲ N. Burnell, L. Schwartz, Julius Tischkewictsch, Ray Bello, Marty Nemiroff, ▲ Bernie Teinerman, Nat Cohen



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Burr-Brown Research Corp., Booth 3052
Box 6444
Tucson, Ariz.

▲ Thomas R. Brown

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Burroughs Corporation
Electronic Tube Div.
P.O. Box 1226
Plainfield, N.J.
Booths 1211-1215

A. Shesser, ▲ S. Kuchinsky, ▲ R. Wolfe, ▲ J. Bethke, R. Brady, P. Nace, R. Driscoll, G. Arndt

Beam-X Transistor Decade Counter

A complete line of digital devices including *New BEAM-X® Switch; Beam Switching Tubes; Long Life NIXIE® Indicator Tubes; *TRIXIE® Transistor Readout; *Transistor—BEAM-X Switch Decade Counters; Solid State Frequency Dividers; *Miniature Incandescent Readouts; Mil Decade Counters; Pulse Control Equipment; Beamplexer.

Burton-Rogers Co., Booth M-17
See: Hoyt Electrical Instrument Works.

▲ Indicates IRE member.
* Indicates new product.

Bussmann Mfg. Division
McGraw-Edison Co.
University at Jefferson
St. Louis 7, Mo.
Booth 2737

A. L. Branning, C. J. Dane, T. P. Lawless, A. H. Lucas, J. D. Rambo, E. F. H. Harvell, F. M. Sibley

BUSS Add-On Fuse Blocks

*New BUSS Add-On Fuse Blocks simplify protection of solenoids, small motors, or control apparatus on multiple circuit equipment. May be assembled into unit fuse block of one or many poles. Single pole blocks interlock when a boss slips into recess in bottom of adjacent block. Each unit locked in place by a single screw.

(Continued on page 208A)

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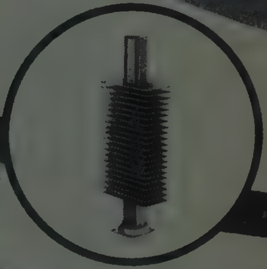

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50 mc/s to 12 kmc/s • Broad band—Octave band—Narrow band • −50 dbm to −65 dbm Tangential Sensitivity

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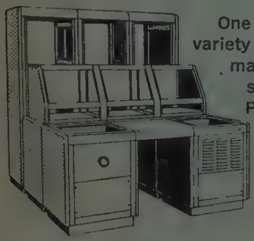

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127 Grace Street, Plainview, N. Y.
IN CANADA: PREMIER METAL HOUSINGS, Ltd.,
5810 Smart Avenue, Montreal

Whom and What to See at the Radio Engineering Show

(Continued from page 206A)

**CBS Electronics Div.,
Columbia Broadcasting
System, Inc.
100 Endicott St.
Danvers, Mass.
Booths 1208-1210**

Q. Adams, ▲ W. Bevitt, ▲ E. Boise, ▲ R. Crosby, ▲ J. Cunningham, C. Dibling, ▲ R. Gibson, ▲ J. Shenk, ▲ R. Swain, R. Tomer, G. Wilde, ▲ R. Yeiter

CBS Electronics will display microelectronics, 0.015% AQL indium-bonded diodes, NPN switching transistors, complementary NPN and PNP power transistors and frame-grid tubes. Also exhibited will be entertainment receiving tubes, audio components, secondary-emission tubes, krytrons, and other specialized tubes for instrument applications.

**CBS Laboratories, Div. Columbia Broadcasting System, Inc., Booth 3063
High Ridge Road
Stamford, Conn.**

David Alan Safer

Vidiac Generator, Vac Bearings Systems.

**CGS Laboratories, Inc., Booths 3803-3805
Wilton, Conn.**

▲ M. L. Jackson, W. L. Gustavson, A. Winter, J. L. Gray

*Antenna multicoupler for 2-32 mc; *50-100 mc panoramic receiver; *miniature INCREDUCTOR high frequency saturable reactors; *tunnel diode characteristic tester; Morse to teleprinter code converter.

**C & K Components, Inc., Booth 1627
101 Morse St.
Newton 58, Mass.**

▲ Robert H. Sturdy, ▲ Charles M. Sutherland, Marshall M. Kincaid, ▲ Charles A. Coolidge, David E. Miller, Robert Clonan, Richard H. Shute, ▲ Franklin Hobbs

Encapsulated magnetic shift registers; encapsulated logic elements; custom encapsulation service; preset electronic counters; transistorized indicator lights*.

**C W S Waveguide Corp., Booths 1313-1315
301 West Hoffman Ave.
Lindenhurst, L.I., N.Y.**

Carl W. Schutter, Ing Bian Oei, V. Schutter, S. Amir, J. Ashman

Dummy Antenna—Coaxial Connectors & Switches—Couplings—Directional Couplers—Crystal Mounts—Duplexers—Adapters—Rotary Joints—Horns—Rigid Waveguides.

▲ Indicates IRE member.
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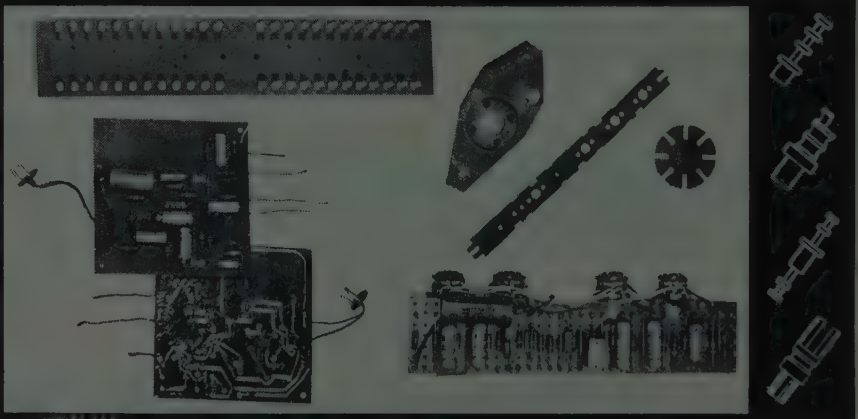

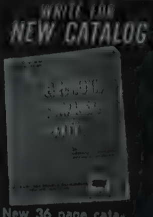

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Calidyne Co., Booths 3802-3804
See: Ling Electronics, Inc.

California Technical Industries, Div. of Textron Inc., Booths 3920-3922
1421 Old County Rd.
Belmont, Calif.

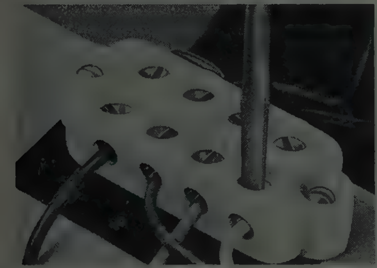
Edwin J. Bradley

Automatic Test Equiment, Cable Testers, Microwave Test Instruments, Tape Punches, Readers and Duplicators, *Military Cable Tester.

Camblock Corp.
Div. Willor Mfg. Corp.
825 Bronx River Ave.
New York 72, N.Y.

Booth 2002

Ben Doktor, Maurice Ross, Bill Aronoff



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445 Concord Ave.
Cambridge 38, Mass.

T. E. Stearns, D. G. Miller, W. D. Frazier, W. A. Melanson, L. L. Wilkes, F. Schaper, R. Goepfert, R. Demeritt, R. Smith

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3208 Humboldt St.
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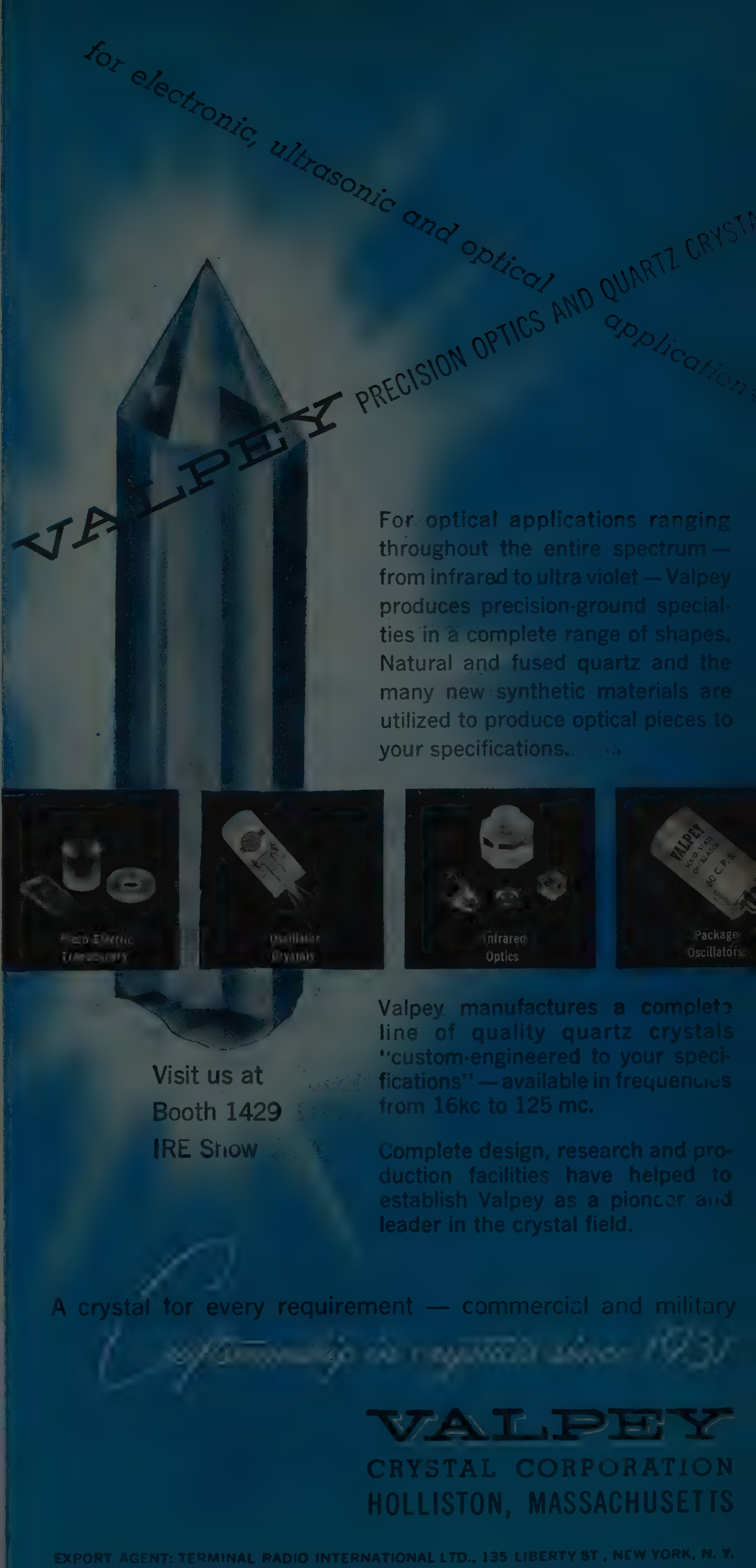
Booths 2628-2632

F. Cate, O. Olsen, B. Davison, W. Conover, H. Schubert, D. Chess, L. St. Pierre, G. Sunderland, B. Moore, B. McCoy, B. Rand, B. Borden, H. Kahn, F. Darcy.

Multi-contact electrical plug design development and manufacture. *MORPHO hermaphroditic modular connectors. *KQ/KR miniature MS type series. *GOLDEN D monobloc subminiatures with snap-in coaxial contacts. *UHF crimp type plugs. *Automatic crimp tools. Series of MS type plugs and Audio plugs.

(Continued on page 210A)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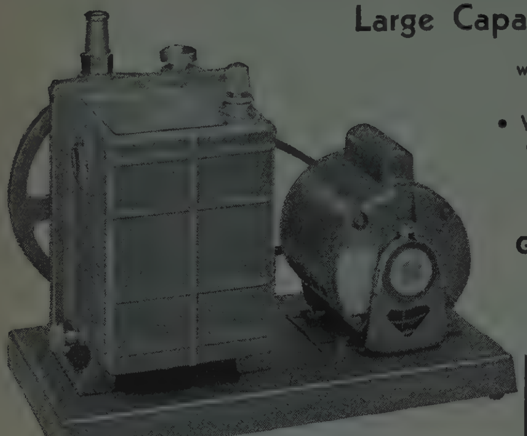

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Rhenium
Rhodium
Rubidium
Ruthenium
Scandium
Selenium
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very small currents

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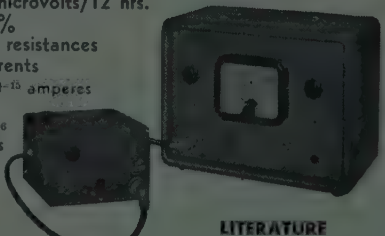
MODEL 33C Industrial Type to 10^{16} ohms and 10-15 amps

MODEL 33C LABORATORY TYPE to 10^{18} ohms and 10^{-16} amps



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27 PARK PLACE, NEW YORK 7, N.Y.

LITERATURE UPON REQUEST

Whom and What to See at the Radio Engineering Show

(Continued from page 209A)

The Capitol Machine Co.
36 Balmforth Ave.
Danbury, Conn.
Booth 2736

Arthur E. Wilson

Capitol Circuit Selector Switches, Lever and Push button.

Capitol Radio Engineering Institute, Inc.
3224 Sixteenth St., N.W.
Washington 10, D.C.
Booth 4430

▲ E. H. Rietzke, ▲ L. M. Upchurch, Jr., ▲ Norman Potter, Henry Hillman, Earl Maze, ▲ Henry I. Metz, Karl O. Bathke, ▲ Arthur Harvey

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Capitron Division, Booth 2527
See: AMP Incorporated, Capitron Div.

The Carborundum Co.
Refractories Div.
Perth Amboy, N.J.
Booths 2930-2931

▲ H. R. Emes, L. E. Buyer, ▲ L. H. Hardy, ▲ R. E. Flynn, T. J. Kuehn, E. Stravs, D. C. Warren, E. Fagan, ▲ K. T. Robinson, J. Barr, J. Harper, C. Menozzi

Thermistors, Varistors, Fixed Non-Inductive Resistors, R. F. Dummy Loads, Ceramics, Kovar Alloy, Ceramic-Metal Assemblies, Alumina Bubbles, Boron Nitride.

Carlisle Corp., Booth 4330
See: Tensolite Insulated Wire Co., Inc.

Carr Fastener Div., United-Carr Fastener Corp., Booth 2536
See: Cinch Mfg. Company.

Carrier Corp., Booths 1907-1909
See: Spectrol Electronics Corp.

(Continued on page 212A)

Keep this book for future reference, so you will be able to remember "Who made it?" and discover "Where can I reach them now?"

IS *YOUR* COMPANY ON THE *OFFENSE* FOR *DEFENSE?*

SIGNAL is your introduction to the men who control the growing $4 billion dollar government radio-electronics spending

---

Never before have our armed forces so badly needed the thinking and products of the electronics industry. Advertising in SIGNAL, the official journal of the *Armed Forces Communications and Electronics Association,* puts you in touch with almost 10,000 of the most successful men in the field—every one a prospect for your defense products!

Share in the defense and the profits! Company membership in the AFCEA, with SIGNAL as your spokesman, puts you in touch with government decision-makers!

SIGNAL serves liaison duty between the armed forces and industry. It informs manufacturers about the latest government projects and military needs, while it lets armed forces buyers know what *you* have to offer to contribute to our armed might. SIGNAL coordinates needs with available products and makes developments possible.

But SIGNAL is more than just a magazine. It's *part of an over-all plan!*

A concerted *offensive* to let the government, which has great faith in industry and the private individual producer, know exactly what's available to launch its far-sighted plans. Part of this offensive is the giant AFCEA National Convention and Exhibit (held this year in Washington, D.C., June 3-5). Here, you can *show* what you have to contribute directly to the important buyers. Your sales team meets fellow manufacturers and military purchasers and keeps "on top" of current government needs and market news.

Besides *advertising* in SIGNAL which affords year-round exposure by focusing your firm and products directly on the proper market . . . besides *participation* in the huge AFCEA National Convention and Exhibit . . . the over-all plan of company membership in the AFCEA *gives your firm a highly influential organization's experience and prestige to draw upon.*

As a member, you join some 170 group members who feel the chances of winning million dollar contracts are worth the relatively low investment of time and money. On a local basis, you organize your team (9 of your top men with you as manager and team captain), attend monthly chapter meetings and dinners, meet defense buyers, procurement agents and sub-contractors. Like the other 48 local chapters of the AFCEA, your team gets to know the "right" people.

In effect, company membership in the AFCEA is a "three-barrelled" offensive aimed at putting your company in the "elite" group of government contractors—the group that, for example in 1957, for less than $8,000 (for the full AFCEA plan) made an amazing total of *459.7 million dollars!*

This "three-barrelled" offensive consists of

(1) Concentrated advertising coverage in SIGNAL, the official publication of the AFCEA;

(2) Group membership in the AFCEA, a select organization specializing in all aspects of production and sales in our growing communications and electronics industry; and

(3) Attending AFCEA chapter meetings, dinners and a big annual exposition for publicizing your firm and displaying your products.

If *you're* in the field of communications and electronics . . . and want prestige, contacts and exposure . . . let SIGNAL put your company on the *offense* for *defense!* Call or write for more details—now!

SIGNAL

BPA

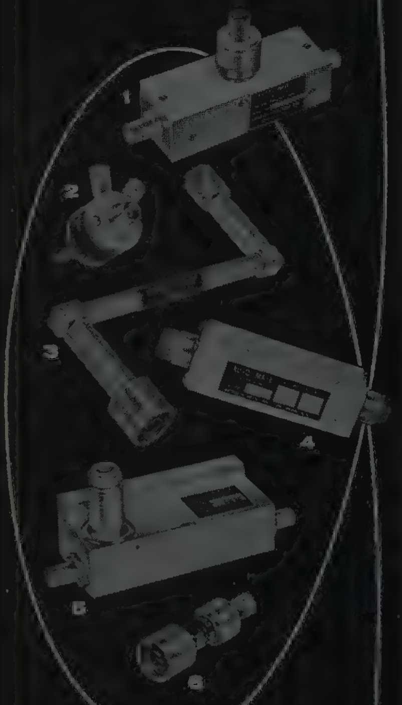
Official Journal of AFCEA

Wm. C. Copp & Associates

72 West 45th Street, New York 36, New York
MUrray Hill 2-6606
Boston · Chicago · Minneapolis
Los Angeles · San Francisco

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION

Automatic*
designs
and
manufactures
Complete
Coaxial
Systems



1. 30db SAMPLER
2. SPDT SWITCH
3. LOW PASS FILTER
4. 5db ATTENUATOR
5. 10db DIRECTIONAL COUPLER
6. CRYSTAL DETECTOR
AND . . . CONNECTORS, OF COURSE!

*Automatic
METAL PRODUCTS CORPORATION
323 BERRY STREET, BROOKLYN 11, N.Y.
EVergreen 8-6057

Booth 1524 • IRE Show • N.Y. Coliseum

Whom and What to See at the Radio Engineering Show

(Continued from page 210A)

Carter Parts Co., Booth 2109
3401 W. Madison St.
Skokie, Ill.

N. Frantz

IMP molded jacks, IMP phoneplugs, *IMPY subminiature jacks, *IMPY subminiature phone plugs, IMP push-button switches, telephone jacks, jack strips. GNOME wirewound controls, adjustable wirewound resistor, *IMP lever switch, *IMP multiple circuit jacks, *IMP rotary switches, *IMP push-button switches.

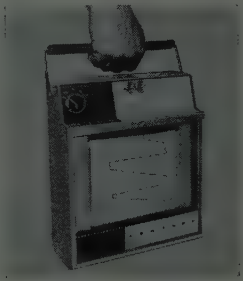
Centronix, Inc., Booth 3934
4000 N.W. 28th St.
Miami 42, Fla.

▲ Garth E. Bower, Sigmund P. Rosen, Daniel R. Kursman, Jerome Kursman, ▲ Ralph Weinger, ▲ Winston Starks, Bob Cameron, Paul Stock, Bernie Spector

Direct Writing Chart Recorders, Marine Depthmeter*, Marine Radio Transceivers*, Transistor Citizens Band Transceiver*, Coils, Transistor Analyzer*, Audio Analyzer*, Radio & TV Service Test Equipment, "Aquavox" Underwater Communications Equipment.

Century Electronics & Instruments, Inc.
1333 North Utica St., Box 6216
Tulsa, Okla.
Booths 3608-3610

J. M. Simpkins, J. H. Black

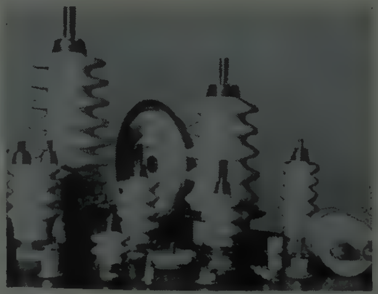


Model 450 Portable Recorder (NULL BALANCE)

*Strainistor strain gages; *portable recorders; *direct writing oscillographs; airborne multichannel oscillographs; *Colorbar visual monitors; bridge control units; carrier and linear integrating amplifiers; *sub-miniature pressure switches.

Ceramaseal, Inc.
Box 25
New Lebanon Center, N.Y.
Booth 1724

Herbert A. Omley, Paul F. Ost, Gene D. Sawin, A. M. Bredbenner



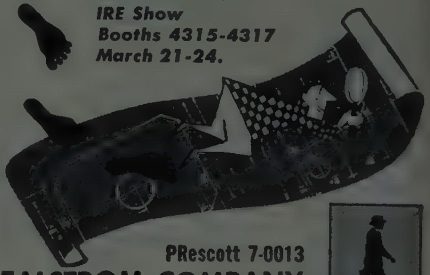
Alumina ceramic-to-metal sealed terminals and bushings, MI cable terminations, thermocouple seals, sapphire-to-metal seals, high pressure seals, magnetron wells, hermetic, brazable, 100% mass spectrometer leak-tested, operating voltages to 100 KV-DC. New high reliability porcelain-to-metal* sealed bushings.

(Continued on page 213A)

Reading the small print!

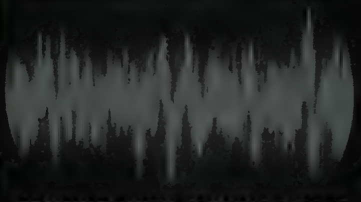
That's important in metal fabrications because small errors can cause big trouble. The special care taken by Falstrom in analyzing your blueprints will give you a better job at a more economical cost.

See us at the IRE Show Booths 4315-4317 March 21-24.



PRescott 7-0013
FALSTROM COMPANY
74 A Falstrom Court • Passaic, N. J.

AMPLIFIER NOISE PROBLEMS?



CONSULT WITH MILLIVAC FIRST

We make several low-noise amplifiers which differ from each other in gain, input-impedance and frequency range. For further information, visit us at Cohu headquarters.

BOOTHS 3401-3411

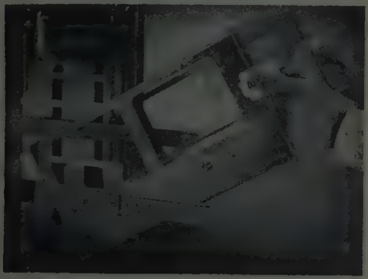
MILLIVAC
A DIVISION OF
COHU
ELECTRONICS, INC.
Box 997 Schenectady, New York

Whom and What to See at the Radio Engineering Show

(Continued from page 212A)

Chassis-Trak, Inc.
525 S. Webster Ave.
Indianapolis 19, Ind.
Booth 4001

▲ Larry M. Vaughn, Sarah Gray, Lou Flagin, John McShay



The complete line of slides for electronic cabinets and chassis. Pencil thin slides support from 50 to 275 lbs . . . tilt, non-tilt and detent models. Complete line of chassis handles. Factory assembled, pre-aligned, front rail (gusset) slide assemblies.

Chatham Electronics Div., Booths 2428-2430, 2521-2523

See: Tung-Sol Electric, Inc.

Chemo Products, Inc., Booth 4056
100 Pulaski St., P.O. Box 169
West Warwick, R.I.

William R. Rawdon, Ernest Nathan, Herbert Whitaker, Albert C. Tieniber, Hugo DiClemente

Teflon Skived Sintered Tape—Teflon Molded Rod, Sheet and Tube Teflon Extruded Rod and Tubing—Fabricated Parts of Teflon Yarns coated with Vinyl, Teflon, Silicone, Latex and other coatings.

Chicago Aerial Industries, Inc., Kintronic Division, Booth M-23
10134 Pacific Ave.
Franklin Park, Ill.

G. B. Baumeister, Erik Normann, Rauol Gott, William Gold

*New low cost precision potentiometer line; high speed long life potentiometers; *ultra high temperature precision potentiometers of all stainless steel construction. *Engineered assemblies of servo motors, pots, etc.; high speed rotary commutator switches.

Chicago Dynamic Industries, Inc.
Precision Products Division
1725 Diversey Blvd.
Chicago 14, Ill.
Booth M-18

J. C. Koci, ▲ S. Heide

Removable wafer rotary switch, Removable wafer thumbwheel switch, Precision counters.

Chicago Standard Transformer Corp.
3501 West Addison St.
Chicago 18, Ill.
Booth 1216

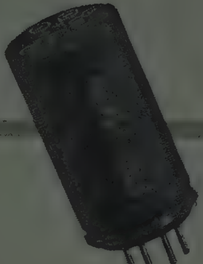
A. W. Johnson, E. M. Keys, P. N. Cook, R. K. Burns, Oliver Williams, Vern Howell

A complete line of transformers and Reactors for electronic applications in military, industrial, communications, radio and television equipment.

(Continued on page 214A)

AIRPAX

EXHIBITING IN BOOTHS 2306 - 08 AT THE IRE SHOW

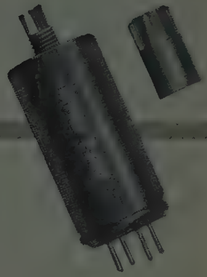


TRANSISTOR CHOPPER

Miniature transistor chopper with self-contained drive transformer operates from fifty to five thousand CPS.

PREAC AMPLIFIERS

Preac magnetic amplifiers are high sensitivity DC units having an extremely stable null. For 60 and 400 CPS sources.



CHOPPER TYPE 2300

Low noise type for null seeking servos, instrumentation, instrument amplifiers, telemetering and control systems.

FERRAC
AMPL

FERRAC MOLDED AMPLIFIER

Fast response, wide dynamic range and high gain characterize this rugged Ferrac molded magnetic amplifier. Weight only 7.5 ounces.

AIRPAX FM TELEMETRY MONITOR

Nine channel FM Telemetry Monitor. Deviation from center frequency of each telemetry sub-channel is displayed and measured.

INSTANTANEOUS ACTING
MINIATURE
MAGNETIC CIRCUIT BREAKERS

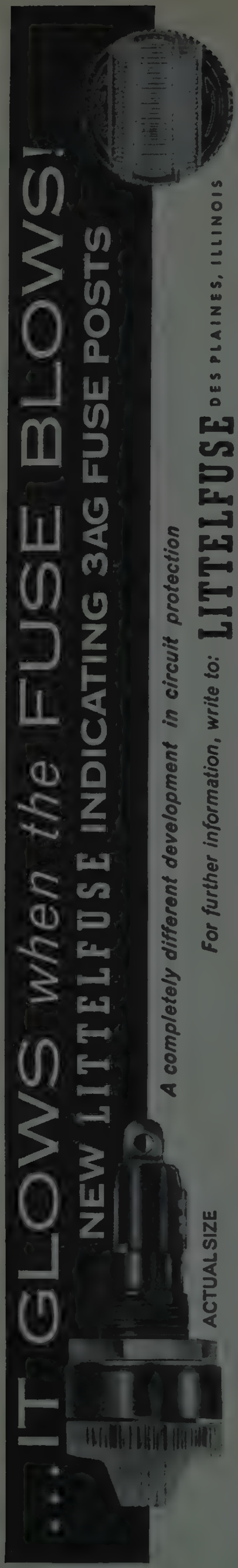
Miniature hermetically sealed magnetic circuit breakers with inverse time delay provide positive protection in critical circuits. Trip level is independent of temperature.

Airpax engineers resolve the most advanced technological problems met with in the fast-moving electronics and electro-mechanical fields. Subminiaturization, abnormal temperatures, super-reliability, space utilization and similar subjects are constantly under investigation in the quest for designs to meet the demands of tomorrow.

AIRPAX ELECTRONICS INCORPORATED

CAMBRIDGE, MARYLAND FORT LAUDERDALE, FLORIDA

AB11


...IT GLOWS when the FUSE BLOWS!
NEW LITTELFUSE INDICATING 3AG FUSE POSTS
A completely different development in circuit protection
For further information, write to: LITTELFUSE DES PLAINES, ILLINOIS
ACTUAL SIZE

Whom and What to See at the Radio Engineering Show

(Continued from page 213A)

Chicago Telephone Supply Corp.
1142-1232 Beardsley Ave.
Elkhart, Ind.
Booth 1400

C. R. Beitner, Duncan Handley, R. J. Masten, H. L. Slough, J. C. Tidwell

Miniature
CERATROLS
with new metal ceramic element

Miniature CeraTrolS Potentiometer

Variable resistors and associated switches, Trolex rotary wafer switches* and TV tuner wafers*, Motor Driven potentiometers*, metal film potentiometers*, tubesavers*, rotary, pull-push*, and push-push* power switches, bobbinless wirebound fixed precision resistors* and sub-miniature variable resistors for hearing aids*.

Chilton Publishing Co., Booths 4301-4303

See: Electronic Industries.

Christie Electric Corp., Booth 2911
3410 W. 67th St.
Los Angeles 43, Calif.

▲ Fred Benjamin

A complete line of Automatic Battery Chargers for lead acid, nickel cadmium, silver zinc, silver cadmium and Edison batteries. Also displayed will be Christie's line of commercial and militarized D-C Power Supplies.

Cinch Mfg. Company
1026 S. Homan Ave.
Chicago 24, Ill.
Booths 2535-2536

E. J. Pool, S. Pfannstiehl, ▲ G. H. Hunt, J. L. Elsley, G. S. Maynard, R. K. Byers, E. P. DiMarco, C. W. Nelson, J. M. Litman, Grenfell Older, George Hart, A. R. Kimbell, R. I. Jones, R. Bengtson

Tube sockets and shields, micro-connectors, terminal strips, battery plugs and sockets, transistor sockets, semiconductor components, strapnuts, T-nuts, tube holders, metal stampings, printed circuit boards, printed circuit sockets and components, plug buttons, push button covers, cabinet tee nuts, trimounts, battery connectors, plastic mounting feet, glide and ferrule combinations.

Cinch Mfg. Company, Howard B. Jones Div., Booth 2535

See: Howard B. Jones Div.

Circo Ultrasonic Corporation, Booth 4509
51 Terminal Ave.
Clark, N.J.

Wellington Vandeveer, Severn S. Carlson, ▲ Benson Carlin, Richard Gartley, K. Wm. Ostrom

Manufacturers of Ultrasonic Cleaning Equipment and *Ultrasonic Test Equipment. Specialists in Large Automated Systems. Pioneer in Field of Ultrasonic Vapor Degreasing. White Room Units for Ultra Clean Operations.

FIRST AID ROOM
First mezzanine. Take elevator 20 from north side of any floor.

C. P. Clare & Co.
3101 West Pratt Blvd.
Chicago 45, Ill.
Booths 2218-2220

Harold W. West, John M. Grofik, James H. Riley, M. J. Ryan, Tom Buroojy, R. Shires, F. J. Wilmot, Ed Holt, A. E. Corwith, Robert E. Kleiner

Mercury-Wetted Contact Relays Are Offered In A Full Line of Packages Including Printed Circuit Boards. The CLAREED, A Sealed Contact Reed Relay, Will Be Introduced. Stepping Switches, Telephone-Type Relays, And Miniature Relays Will Also Be Displayed.

Clevite Corporation, Brush Instruments Division, Booths 2616-2626
37th and Perkins
Cleveland 14, Ohio

J. H. Harris, ▲ N. R. Klivans, R. Von Kamecke, W. K. Whittemore, ▲ D. E. Pierce

Amplifiers—Oscillographs—Direct Writing Recording Systems—Operations Monitors—Brush Recorder Mark II—Metrisite.

Clevite Corp., Clevite Electronic Components Div., Booths 2616-2626
3405 Perkins Ave.
Cleveland 14, Ohio

M. R. Eastin, G. E. Eubanks, K. W. Henderson, R. M. Jewitt, M. J. Luch, J. A. Mahoney, Don Markeson

Self-Generating Accelerometers*, "Transfilters" and Ceramic Ladder Filters, Magnetic Recording Heads and Accessories, Piezoelectric Crystal and Ceramic Transducer Elements.

Clevite Corp.
Clevite Transistor Products Div.
241-257 Crescent St.
Waltham 54, Mass.
Booths 2616-2626

▲ Allen J. Dusault, Samuel Rubinovitz, ▲ Phillip N. Seidenberg, ▲ Linwood C. Huff, Phillip Goodman, ▲ Edward A. Cushman, Donald Smith, ▲ Eli Mitchell, Louis Norris, Robert S. Humphrey, S. Leitzell, Edward Barry

Germanium and Silicon Transistors and Diodes.

Cobehn, Inc.
226 Passaic Ave.
Caldwell, N.J.
Booth 4106

▲ George L. Henzel, William E. Bellars, Alvin M. Cohan

Precision Parts Cleaner Model RT-S-8-6

Display and Demonstration of Manual and Automatic High Velocity Spray Equipment and Solvents for the Critical Cleaning of Precision Electrical, Electronic, and Electro Mechanical Components.

▲ Indicates IRE member.
* Indicates new product.

Sigmund Cohn Corp.
121 S. Columbus Ave.
Mount Vernon, N.Y.
Booths 4322-4324

Frank Krombach, Richard Cohn, James Cohn, ▲ H. M. Lang, Dr. B. Brenner

Sigmund Cohn Spools

Base metals, precious metals fine wire and ribbon, bare drawn, etched electroplated, enamel insulated. PYROFUZE.

Cohu Electronics, Inc., Booths 3607-3617
See: KinTel Div., Massa Labs., and Millivac Instruments.

Coil Winding Equipment Co.
19 Maxwell Ave.
Oyster Bay, L.I., N.Y.
Booth 4426

▲ Howard A. George, ▲ Blanche A. George, James H. George, Andrew Sallade, Lloyd George, William E. Summerbell, P. W. Newell, Jr., John Byrne, John Raswick, John Slater

Operator-Less Bobbin Winding Machine

Emphasis on automatic and semi-automatic turret-type winders. Also a line of laboratory and conventional machines for winding all coils including lattice, bobbin and paper interleaved types. Stator winders which will wind internally and externally slotted lamination stacks.

Collins Electronics Mfg. Corp., Booth 1117
Stevensville, Md.

L. H. Collins, William H. Reid, ▲ H. J. Wise, Seymour Hunt, ▲ J. A. Simberkoff, ▲ S. W. Simberkoff, H. Lewis, A. Linke, R. Scholfield
DC-AC Choppers, Miniature General Purpose, Miniature Low Noise, Ultra-Low Noise, Single-Pole-Single-Throw, Double-Pole-Double-Throw, Break-Before-Make, Make-Before-Break, also special types custom designed and produced.

Collins Radio Co.
P.O. Box 1891
Dallas 21, Tex.
Booths 3502-3508

W. W. Roodhouse, C. S. Carney, W. E. Fells, G. M. Bergmann, R. D. Brummer, W. G. Dostal, B. Farquhar, L. H. Leggett, P. E. Magdeberger, R. B. Prewitt, J. S. Ward, C. P. Glade
Specializing in radio communication and navigation for ground, airborne and space applications. Facilities for design, production, installation, and management of complete systems.

Collins Radio Co., Booths 2809-2811
See: Communications Accessories Co.

(Continued on page 216A)

elin
3-phase
50 VA
Power Supply

Model MK-150

Ultra-stable, fine line characteristics — the kind you need and can depend on, are in ELIN's latest 3-phase 50 VA Power Source! Voltage and current sensing on each leg provide super-regulated output. Delta and Wye connections are at rear panel. Input Voltage, 105-125V, single phase. Input Power 225W. Output Voltage ±0.1%. Output Frequency ±0.1%. Output Regulation 0.1% Line to Line. Output Distortion 0.2%. Load Power Factor up to 0.3 inductive. Write for ELIN Technical Data—today!

precision power oscillators/voltage calibrators/multi-phase power supplies

elin division
International Electronic Research Corporation
145 West Magnolia Boulevard, Burbank, California

JERROLD

R. F. Test Equipment

Quantitative Measurements Using Sweep Frequency Techniques

Model 900A—THE MOST VERSATILE SWEEP GENERATOR $1,260^00

CENTER FREQUENCY—VHF 0.5 to 400 MC UHF 275 to 1000 MCS—SWEEP WIDTH—up to 400 MCS—FLATNESS—±0.5 db over widest sweep!

Model 707—ULTRA FLAT SWEEP GENERATOR $795^00

Featuring ±5/100 db flatness—Plug-in osc. heads; variable sweep rates from 1/min. to 60/sec.; all electronic sweep fundamental frequencies; sweep width min. of 1% to 120% of C.F.*

*Heads available within the spectrum 2 to 265 MCS

Models 601/602—PORTABLE GENERAL PURPOSE $295.00

COVERAGE—Model 601—12 to 220 MCS. Model 602—4 to 112 MCS—FLATNESS — ±0.5 db OUTPUT—up to 2.5 V RMS WIDTH-1% to 120% of C.F.

Model FD-30 $250.00

High speed DPDT coaxial switch permitting oscilloscope measurements without calibration—all measurements referenced continuously against standard attenuators.

Model AV-50 Variable Precision Attenuator $150.00

Long life rotary switches; dual wiping silver contacts on "Kel-F" dielectric. 0-62.5 db in ½ db steps; DC to 500 MCS.

Write for catalog and technical Newsletter series on measurements using sweep frequency techniques. Prices and data subject to change without notice.

JERROLD ELECTRONICS CORPORATION
Industrial Products Division Dept. ITE-12
The Jerrold Building, Philadelphia 32, Pa.
Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N.Y. 16, N.Y.

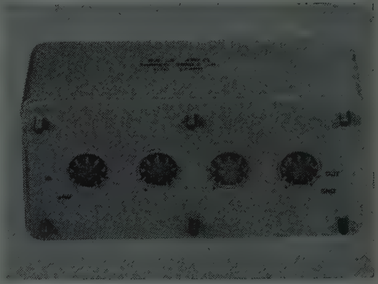
Whom and What to See at the Radio Engineering Show

(Continued from page 215A)

Columbia Broadcasting System, Inc., Booths 1208-1210 & 3063
See: CBS Electronics Div. & CBS Laboratories Div.

Columbia Technical Corp.
61-02 31st Ave.
Woodside 77, N.Y.
Booth 1112

V. Liebmann, ▲ J. Machill, ▲ D. R. Stein, G. H. Weiland, N. Ordjanian



Lumped-Parameter Delay Line

Distributed and *Lumped-Parameter Delay Lines with delay-to-rise time ratios of up to 100, MiniLine miniature and sub-miniature encapsulated delay lines, Magnetic-Core Delay Cables, Delay Line Flats, *Audio Delay Lines. Humi-Seal protective coatings for electronic parts and assemblies.

Columbus Electric Mfg. Co., Booth 1120
2005 E. Main St.
Columbus 5, Ohio

F. G. McCloskey, Bob Hancox

Precision snap switches, low cost slow break switch*, temperature control.

Columbus Electronics Corp.
1010 Saw Mill River Rd.
Yonkers, N.Y.
Booth 1928

▲ M. Goetzl, ▲ M. Lowenstein, G. Bard, F. Foye, R. Siek, H. Kleinick

Up to 2,000 PIV

Over 250 JEDEC Types of Hermetically Sealed, Double Diffused Silicon Rectifiers. Single Units from 50 to 2,000 PIV. Epoxy Block Combinations to 12 KV. Custom Combinations, Single or Multi-Phased, to 32 KV, 12 AMPS.

Colvern Limited, Booth 1820
See: British Radio Electronics Ltd.

▲ Indicates IRE member.
* Indicates new product.

Comar Electric Co.
3349 West Addison St.
Chicago 18, Ill.
Booth 2927

L. E. Noelck, L. D. Chocola, R. Valleau

Relays (including hermetically sealed), solenoids, coils and switches.

Combined Book Exhibit, Inc., Booth 4031
950 University Ave.
New York 52, N.Y.

Thomas J. McLaughlin, A. L. Remly, Dolores Carrio, Harry A. Simmons, William G. Tarbox

Recent technical books of many leading publishers, arranged by subject. A bibliography for Radio Engineers has been prepared and is given free at this booth.

Communication Accessories Co., Subsidiary of Collins Radio Co., Booths 2809-2811
Highway 71, By-Pass & U.S. 50
Lee's Summit, Mo.

▲ Carl R. Rollert, ▲ Walter Kunde, William J. Monroe, ▲ Joseph L. Brickner

High quality magnetic components, molded coils, MIL transformers, magnetic amplifiers, LC filters. Special designs of the above products solicited.

Computer Control Company, Inc.
983 Concord St.
Framingham, Mass.
Booth 3308-3310

J. I. Leabman, A. A. Aykanian, L. H. Eisner, ▲ W. Wolfson, J. V. Cockin, ▲ B. Kessel, ▲ R. W. Brooks, ▲ F. R. Dean, ▲ W. P. Horton

Digital Computer Module

Digital Computer Modules and Code Bar Switches; special purpose digital systems including information retrieval, data error comparators, coordinate conversion, tape-to-tape converters, automatic control, random access core memories; also stored program computer.

Computer-Measurements Corp., Booths 3103-3104
12970 Bradley Ave.
Sylmar, Calif.

J. K. Rondou, J. L. Cassingham, C. E. Storie, J. B. Olson, E. C. Helme

10 MC Transistorized Universal Counter Timer, Transistor decades, Digital printer, Digital in-line display, frequency counters, time interval meters, pre-set controllers, totalizing counters.

(Continued on page 218A)

The letter "M" preceding a booth number indicates that the exhibitor will be found on the mezzanine at the back of the first floor.

16
HUGGINS LABS. INC.

The most complete line of TWT's

Keeping pace with increasing demands for TWT's, research and development programs are expanding at Huggins.

Underway are studies involving extensions at both ends of the frequency spectrum as well as more detailed efforts on broadband low noise performance. Heavy emphasis is being given to lightweight structures able to provide specific performance in severe environments.

Industry looks to Huggins Laboratories for the world's most complete line of Traveling Wave Tubes.

Here, challenging opportunities exist in an Organization which has pioneered and continued to specialize in TWT's, the versatile equipment that is finding a wider and wider range of applications.

Qualified personnel please submit resumes.

Our Booth at the
IRE Show is
2917-2918
Visit us there

HUGGINS LABORATORIES, INC.

HUGGINS
manufacture
development
engineering
design
research
LABORATORIES

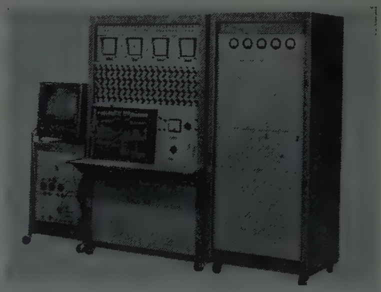
999 East Arques Avenue
Sunnyvale, California
Regent 6-9330

Whom and What to See at the Radio Engineering Show

(Continued from page 216A)

Computer Systems, Inc.
611 Broadway
New York 12, N.Y.
Booths 3837-3839

Robert K. Stern, Charles B. Husick, W. George Van Vliet, Salvatore J. Teta, Jack M. Andrews, Irwin West, B. Brachman, M. Schwartz



DYSTAC (Dynamic Storage Analog Computer)

DYSTAC® (Dynamic Storage Analog Computer) synthesizes the traditional advantages of both analog and digital computers. The analog's speed, lower cost, ease of programming, and improved data presentation are combined with the digital's capacity for data storage and timesharing of computer elements.

Condenser Products Division, New Haven Clock and Watch Co., Booth 2240
140 Hamilton St.
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I. Small

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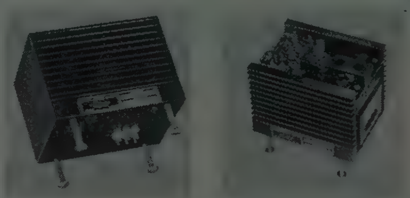

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(Continued on page 219A)

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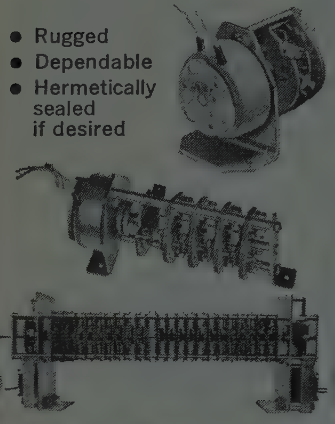

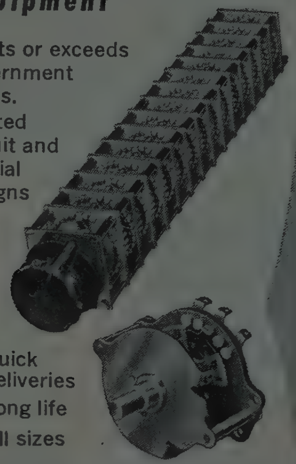

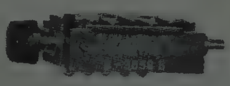

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Whom and What to See at the Radio Engineering Show

(Continued from page 218A)

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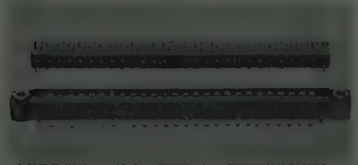

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(Continued on page 220A)

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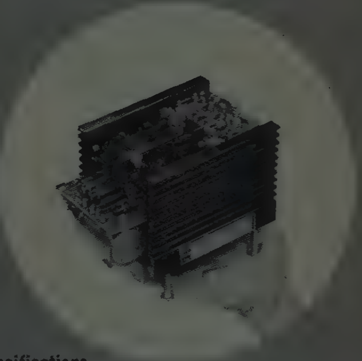

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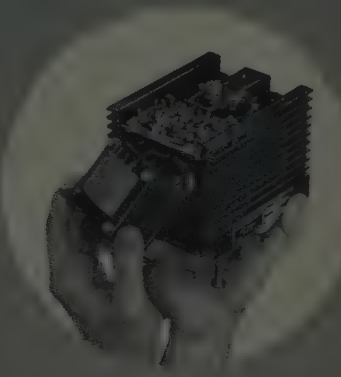

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(Continued from page 219A)

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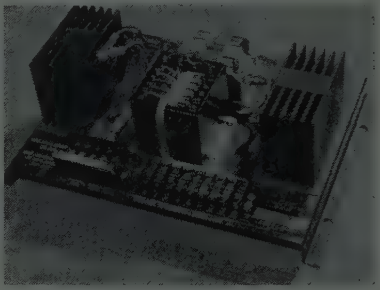

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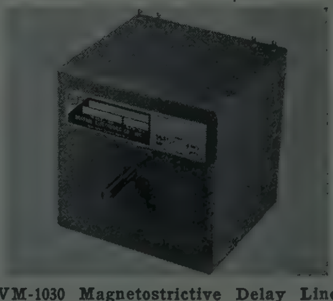

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Control Switch Div., Controls Co. of America, Booths 1727, 1727A, 1727B
See: Hetherington Switch Div & Electrosnap Switch Div.

(Continued on page 221A)

▲ Indicates IRE member.
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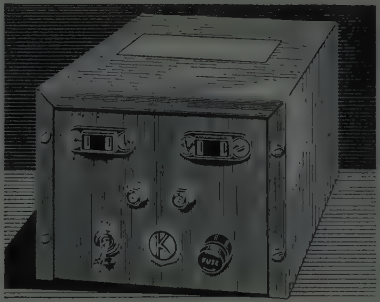

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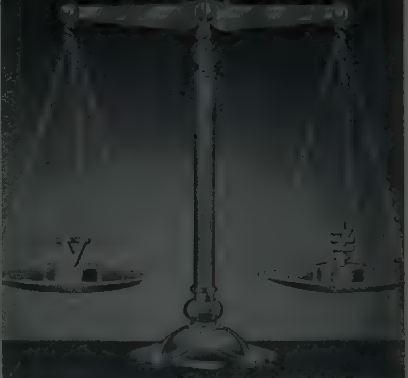

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(Continued from page 220A)

Controls Company of America, Booths 1727, 1727A, 1727B
See: Hetherington Switch Div. & Electrosnap Switch Div.

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Data-Stor Div.
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(Continued on page 222A)

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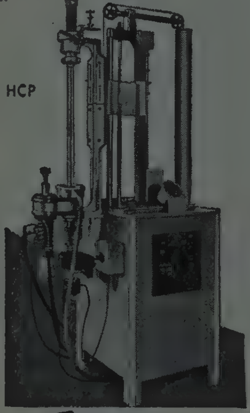

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(Continued from page 221A)

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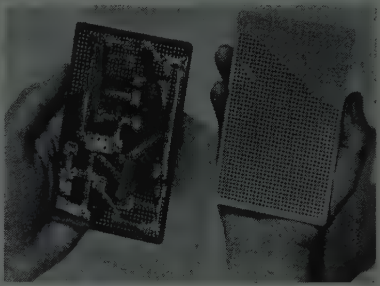

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Semiconductor Products Magazine, CQ Magazine, Technical Books, Technical Publishing Services.

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Crescent Petroleum Corp., Booth 2134

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Crosby-Teletronics Corp., Booths 3312-3314
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Westbury, L.I., N.Y.

▲ Bart Coffman, ▲ Bob Constable, Bob Corbey, ▲ Ted Nelson, ▲ John Peters, ▲ John Simmons, ▲ Hank Schweibert, Frank White

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Crosley Division, Booth 3064

See: Avco Corp., Crosley Div.

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(Continued on page 224A)

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ELECTRONIC TUBES AND SEMICONDUCTORS
ETS Are Franchised Distributors For Most Leading Brands Of Tubes and Semiconductors
REMEMBER! We Are As Close To You As Your Telephone
CALL ETS for LOW COST and OFF THE SHELF DELIVERY

ATTENTION
ENGINEERS PURCHASING AGENTS
Consult The 1960 IRE DIRECTORY For Information Regarding Our NEW-FREE TUBE AND SEMICONDUCTOR REFERENCE BOOK

ELECTRONIC TUBE SALES, INC.
74 Cortlandt St.
New York 7, N.Y.

Whom and What to See at the Radio Engineering Show

(Continued from page 222A)

Curtiss-Wright Corp.
Electronics Division
631 Central Ave.
Carlstadt, N.J.
Booths 1519-1519A

▲ **J. G. Sauer, L. W. Pharmer, D. H. Garretson, V. V. Myers, R. E. Johnson, A. Bertelson, J. Schoenwald**

Time Delay Relays, Solid State Relays, Stepping Motors, Delay Lines, Connectors, Transistor Test Instruments & Systems, Digital Data Acquisition & Processing Systems—Recorders, D E V R (Voltage Regulators), D C E (Electrometer), Portable Test Instruments, D C Amplifiers.

Cutler-Hammer, Inc., Booths 3316-3318, 3413-3417
See: Airborne Instruments Lab. Division.

D & R, Ltd., Booth M-24
402 East Gutierrez St.
Santa Barbara, Calif.

B. C. "Buck" Rogers, Bob Lindbery, ▲ **Ray L. Dawley**

Flutter and wow meters, transistor circuit and special purpose power supplies, hot gas driven turbo-alternators, high frequency alternators, converters for industrial and military applications.

Dage Electric Co., Inc.
67 N. 2nd St.
Beech Grove, Ind.
Booth 2433

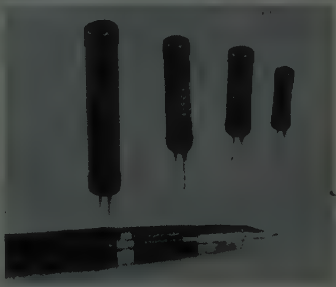
A. N. Strickland, M. H. Burdett, W. O. Slater

Dage Electric will be exhibiting coaxial cable connectors, triaxial cable connectors and glass-to-metal hermetic seals.

Dage Television Div., Booths 1431-1631
See: Thompson Ramo Wooldridge, Inc.

Dale Products, Inc.
1302 28th Ave.
Columbus, Neb.
Booths 2627-2629

I. E. Gates, Dan Geeding, Jim Brandfas, Ray Root, J. Matejka



New Vertically Mounted Resistors

Complete line of resistors, T-pots & hysteresis motors. Featuring *new line of precision wirewound resistors for printed circuits; *new MIL-spec T-pots; *new super miniature power resistor and Dalohm hysteresis gear motor.

▲ Indicates IRE member.
* Indicates new product.

Whom and What to See at the Radio Engineering Show

Danbury-Knudsen Division, Booths 2402-2408, 2501-2507
See: Amphenol-Borg Electronics Corp.

Data-Stor Div., Booth 3110
See: Cook Electric Co.

Datex Corporation, Subsid. Giannini Controls Corp., Booth 3234
1307 S. Myrtle Ave.
Monrovia, Calif.
J. L. Kent
Shaft position encoders, V-scan encoders*, Mini-module chassis*, precision encoder-servo assembly, Gray-to-binary translator*, and other components.

Daven Company
530 W. Mt. Pleasant Ave.
Livingston, N.J.
Booths 2717-2719
▲ Lewis Newman, ▲ Edward L. Grayson, ▲ K. K. Garrison, ▲ C. Gordon Jones, ▲ Frederick A. Schaner, ▲ Edmund H. Newman, ▲ Raymond E. Lafferty
*Transistorized Missile Power Supplies; *Component Part Reliability Assurance Test Equipment; Precision Rotary Switches; Audio, Video and RF Attenuators; Precision Wire Wound Resistors—Encapsulated, High Temperature, Hermetically Sealed, Sub-Miniature; VTVM's; Audio Oscillators; AC, DC Networks; LC Filters; Metal Film Resistors.

Davies Division, Booth 2214
See: Minneapolis-Honeywell.

Daystrom, Incorporated, Booth 1807
430 Mountain Ave.
Murray Hill, N.J.
Ann Mitchell
Electronic Test Equipment, Panel Instruments, Portable Instruments, Relays, Resistors, Gyros, Potentiometers, Hi-Fidelity Equipment and Test Instruments.

Daystrom, Incorporated, Heath Company, Booths 1702 & 1801-1803
See: Heath Company, Daystrom, Incorporated.

Daystrom, Incorporated, Pacific Division, Booths 1704-1706
See: Pacific Division, Daystrom, Incorporated.

Daystrom, Incorporated, Transicoil Division, Booth 1805
See: Transicoil Division, Daystrom, Incorporated.

Daystrom, Incorporated, Weston Instruments Div., Booths 1708-1710 & 1809
See: Weston Instruments Div., Daystrom, Incorporated.

Decade Instruments Co., Booths 3512-3518
See: Kay Electric Co.

(Continued on page 226A)

▲ Indicates IRE member.
* Indicates new product.

Keep this book for future reference, so you will be able to remember "Who made it?" and discover "Where can I reach them now?"

if you have a problem involving
crystal controlled
frequency sources
and filters
spend your
IRE SHOW TIME
to advantage

Stop at
BOOTH 1903

HILL
ELECTRONICS
INC.

MECHANICSBURG, PENNSYLVANIA

HIGH PACKAGE DENSITY!

VK 20
432,000 parts per cu. ft.
Dimensions:
.2" x .2" x .1"

VK 30
192,000 parts per cu. ft.
Dimensions:
.3" x .3" x .1"

VK T.M.

micro-miniature
CERAMIC CAPACITORS

- Decimal dimensioned case
- Max. volumetric efficiency
- Contiguous flush-mount
- 47-10,000 mmf
- 200 vdc without derating
- −55°C to 150°C operation

"VK" capacitors are designed with square precision molded cases in only two sizes and a single standard 0.2" lead spacing for all values. Continuous life and environmental testing, plus 100% tests for Dissipation Factor, Insulation Resistance, and Capacitance guarantee that each "VK" capacitor in your circuit will perform as predicted.

ALSO UNCASED
FOR COMPLETE
ASSEMBLY
ENCAPSULATION

Same electrical characteristics as standard "VK" series. Each unit coated with a resilient protective compound. Dimensions: 47-100 mmf, .100" square; 120-270 mmf, .130" square; 330-1000 mmf, .150" square; 1200-3300 mmf, .250" square; 3900-10,000 mmf, .265" square.

Vitramon® Incorporated
BOX 544 • BRIDGEPORT 1, CONN.

Whom and What to See at the Radio Engineering Show

(Continued from page 225A)

DeJur-Amsco Corporation

45-01 Northern Blvd.
Long Island City 1, N.Y.
Booths 2307-2309

N. J. Geldman, P. J. Morrisey, E. Redgate, S. Dexter, L. Callan, V. Stein, R. Heitz, E. Drewitz, L. Zielinski, E. Brautigam, S. Giovino, J. O'Brien, D. A. Harkavy, J. Grohowski

2" Ball-Bearing Precision Potentiometer

Precision linear and non-linear, single turn potentiometers from ½" to 5", special ½" knob potentiometer*, custom panel instruments including VU and DB, aircraft flight instrument, ruggedized types from ½"* to 3½", elapsed time indicators, and precision electrical Continental Connectors.

Del Electronics Corp.

521 Homestead Ave.
Mount Vernon, N.Y.
Booth 1816

J. G. Delcau, H. J. Di Giovanni, R. Kaufman, D. R. Congiusti, ▲ S. Glassman, I. Brill

Instrumented High Voltage DC Power Supply

Fully Instrumented High Voltage D.C. Power Supplies—Compact Hermetically Sealed High Voltage D.C. Supplies—Regulated D.C. Power Supplies—High Voltage Meter Multipliers—High Voltage Shorting Switches—Low Capacity Filament Transformers—MIL-T-27 Type Transformers—High Voltage Plate and Filament Transformers.

Delco Radio Division

General Motors Corp.
700 East Firmin St.
Kokomo, Ind.
Booth 1226

M. J. Caserio, H. M. Stelzl, D. A. Sandberg, F. W. Young, Robert Earle, James Hicks, Martin Gillmon, Bernard Gershen, ▲ Dr. J. S. Schaffner, Dr. F. E. Jaumot

Delco Radio offers a complete line of commercial and military power transistors in TO 3 and TO 36 packages and 22 and 40 ampere silicon rectifiers. High quality is assured by meticulous care in manufacture and exacting extensive 100% control of quality.

Deltime, Inc., Booth 1725
139 Hoyt St.
Mamaroneck, N.Y.

Mille Stand, Casper M. Bower, George Hoose, Jess Silberstein, ▲ Albert E. Powell, Thomas Dundon

Magnetostrictive delay lines, standard fixed and variable models. New developments in smaller units with higher storage capacity.

Deluxe Coils, Inc.

P.O. Box 318
Wabash, Ind.
Booth 1930

Ronald W. Keipper, James E. Brumbaugh, Lewis Dumbauld, George I. Martin

Luxolene Encapsulated Hi-Volt. Power Pack

HIGH VOLTAGE D.C. POWER PACKS: Epoxy encapsulated, molded to meet MIL E-4970; Range from 2.5 to 25 KV with current ratings to 15 Ma; Feature inherent regulation for line voltage variation and safe, long-term, short-circuit operation. Also exhibited: Conventional, LUXOLENE® Molded, and Ultra-Fine Wire Coils.

DeMornay-Bonardi

780 S. Arroyo Pkwy.
Pasadena, Calif.
Booths 3216-3218

Louis Della Penna, William T. Brock

*** DBW-715 Cavity Wavemeter, 90-140 KMc**

Complete line of microwave test equipment and standard plumbing components from 2.6 to 90 KMc. In addition, a *line of special equipment operating at 90 to 140 KMc. Applicable for systems, microwave spectroscopy and plasma diagnostics.

Dempa Shinbun, Inc., Booth 2935

See: Japan Electric.

Derivation & Tabulation Associates, Inc., Booth 4113
95 Harrison Ave.
West Orange, N.J.

▲ Henry Tulchin, E. L. Ayres

Characteristics Tabulations: Transistors, Semiconductor Diodes & Rectifiers, Microwave Tubes. Updated Semiannually.

Design Tool Corporation, Booth 4122
772 Bergen St.
Brooklyn 38, N.Y.

Carl Kertesz, Wallace Krakauer, John Thompsen, Dudley Bell, Irving Kertesz

*Automatic Spaghetti Attachment, Auto-Former Combination cuts insulation tubing from reels, inserts resistor (etc.) leads in tubing. Leads cut, formed, adjustable—Panto-Sert inserts components over entire printed board—Transistor Lead Fabricator—Axial Lead Straightener and Taper—*Economy Bender—Auto-Solder.

(Continued on page 231A)

▲ Indicates IRE member.
* Indicates new product.

Electron Tube News ...from SYLVANIA

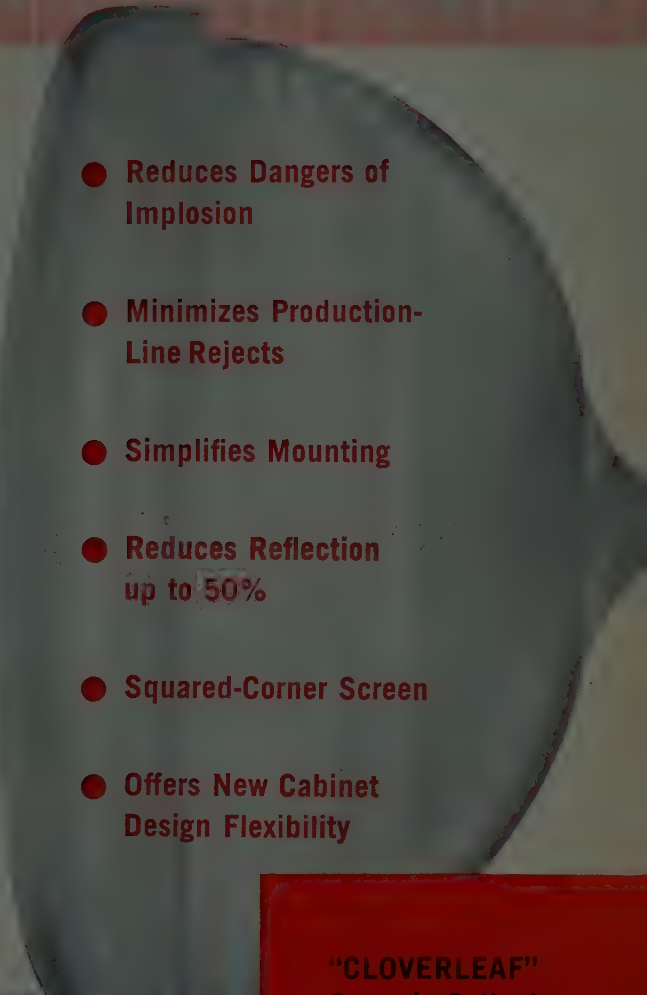
TV PICTURE IS "UP FRONT" SALES ARE, TOO

...when you design around Sylvania 23" and 19" "Bonded Shield" TV picture tubes!

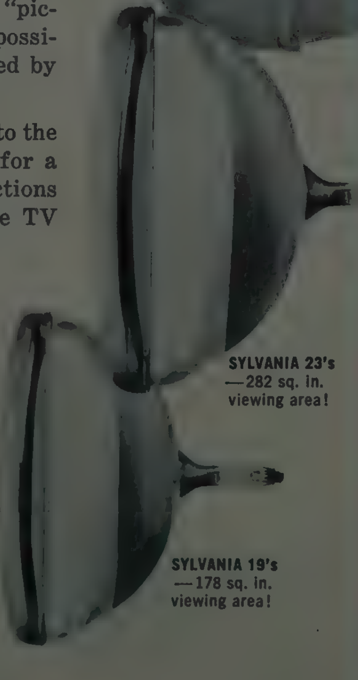
SYLVANIA pioneered the techniques that make possible the quantity production of the new "Bonded Shield" picture tubes for TV sets. SYLVANIA led the way by making "Bonded Shield" picture tubes available to TV set manufacturers in commercial quantities. SYLVANIA was first to demonstrate how "Bonded Shield" eliminates the "picture-in-a-tunnel" effects; first to demonstrate the possibilities of "broad-angle viewing" dramatically offered by this new design.

An annealed-glass scratch-resistant cap is laminated to the face of the tube. It completely eliminates the need for a front-of-the-cabinet safety glass. This reduces reflections that interfere with the brilliance and clarity of the TV picture. Further, it reduces basic requirements for front-to-back dimensions of the TV cabinet, creating new possibilities for cabinet styling and sales appeal. The laminated safety cap eliminates the dust trap between tube face and safety glass. Corners are squared to give larger picture areas. Integral safety-glass and mounting lugs add up to potential savings in costs of cabinetry. Now, "Bonded Shield" picture tubes are also available with non-glare coating. They offer freedom from undesirable reflections and glare.

For technical data and further information, contact the Sylvania Field Office nearest you.



- Reduces Dangers of Implosion
- Minimizes Production-Line Rejects
- Simplifies Mounting
- Reduces Reflection up to 50%
- Squared-Corner Screen
- Offers New Cabinet Design Flexibility



SYLVANIA 23's —282 sq. in. viewing area!

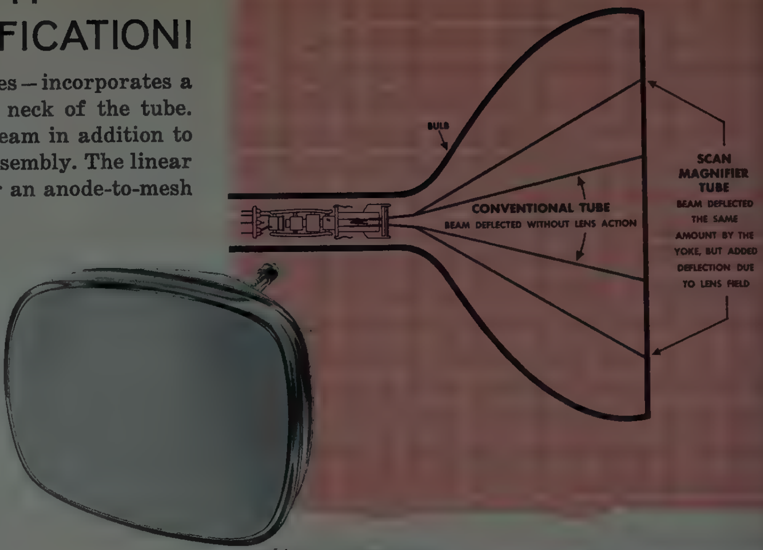
SYLVANIA 19's —178 sq. in. viewing area!

"CLOVERLEAF" Ceramic Cathode Assembly in every "BONDED SHIELD" Picture Tube!

. . . assures fast warm-up time throughout tube life. Sylvania developed this unique structure to reduce heat conduction losses and to give increased durability to the cathode assembly, resulting in improvements in tube life expectancy. For full details on the SYLVANIA "CLOVERLEAF" and its benefits, contact the Sylvania Field Office nearest you.

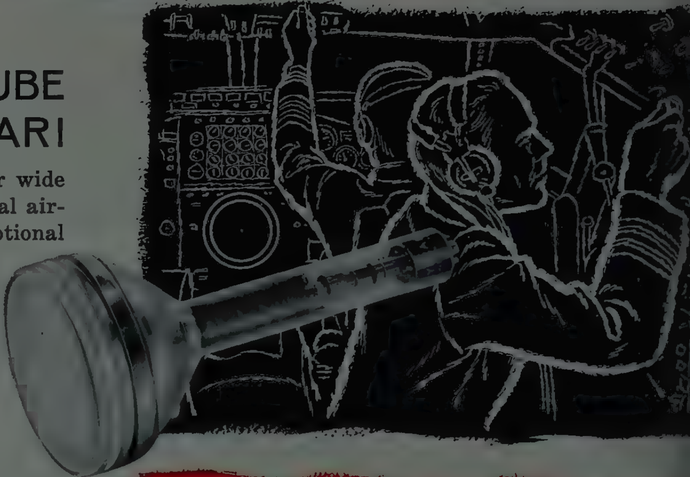
NEW—PICTURE TUBES WITH ELECTRONIC SCAN-MAGNIFICATION!

SYLVANIA ST-2836A—now in the developmental stages—incorporates a mesh-like diverging-lens assembly positioned in the neck of the tube. Its function is to provide deflection of the electron beam in addition to that accomplished by the magnetic field of the yoke assembly. The linear magnification of scan is in the order of two times for an anode-to-mesh voltage ratio of 2 to 1. The primary benefit of such a technique is in the reduction of horizontal-deflection power requirements. It is anticipated that this power requirement may be reduced in practice to as much as 60% of that required for conventional 110° picture tubes. Engineering samples with *low-power heaters* (1.5-volts @ 140 ma., or 12.6-volts @ 150 ma.) and/or low Eg_2 characteristics for a *complete* low-power picture tube are also available. For technical data and further information on SYLVANIA experimental-design SCAN-MAGNIFIED PICTURE TUBES, contact the Sylvania Field Office nearest you.


BULB
CONVENTIONAL TUBE
BEAM DEFLECTED WITHOUT LENS ACTION
SCAN MAGNIFIER TUBE
BEAM DEFLECTED THE SAME AMOUNT BY THE YOKE, BUT ADDED DEFLECTION DUE TO LENS FIELD

NEW—HIGH-VISIBILITY 'SCOPE TUBE FOR AIRBORNE WEATHER RADAR!

SYLVANIA SC-2854 provides improved image brilliance under wide ambient light conditions encountered in cockpits of commercial airliners. The color of the phosphor of this new tube gives exceptional image visibility to dark-adapted as well as to light-adapted eyes. Resolution, too, is exceptionally high. *Sylvania SC-2854* makes possible simplified equipment designs, improved volumetric efficiency and increased life-expectancy of the indicator tube, resulting in reduced costs of installation and maintenance of airborne weather-radar equipment. For details on price and delivery, contact your Sylvania Field Office.



NEW—C.R.T.'S FOR HIGH-ALTITUDE OPERATION TO 70,000 FEET!

Sylvania now makes available a group of direct-view cathode-ray tubes designed specifically for applications in airborne ECM, Radar, and Loran equipment intended for operation at high altitudes. All types feature high quality, nearly flat pressed-glass faceplates. This provides exceptionally clear display and excellent bulb strength. Connections to internal elements are made through insulated leads, encapsulated at points of entry to the bulb. This technique significantly reduces the possibility of corona and arc-over at high altitudes. See data below.

SYLVANIA 5CVP1, 5CVP7, 5CVP19 . . . feature 2¾" x 4¾" direct-view faces, magnetic deflection, electrostatic focus.

MAXIMUM RATINGS (Absolute Maximum Values)

Anode Voltage	4500 Volts dc
Anode Input	6 Watts
Grid No. 4 Voltage (Focusing Electrode)	—500 to +1100 Volts dc
Grid No. 2 Voltage	550 Volts dc
Grid No. 1 Voltage	
Negative Bias Value	165 Volts dc
Positive Bias Value	0 Volts dc
Positive Peak Value	2 Volts
Peak Heater-Cathode Voltage	
Heater Negative with Respect to Cathode	180 Volts
Heater Positive with Respect to Cathode	180 Volts
Altitude	70,000 Feet
Operating Temperature Range	—65 to +85°C

SYLVANIA 3BEP1, 3BEP-* . . . feature 1½" x 3" direct-view faces, electrostatic focus and electrostatic deflection. (-* can be supplied with several other screen phosphors.)

MAXIMUM RATINGS (Absolute Maximum Values)

Anode No. 2 Voltage	3000 Volts dc
Anode No. 1 Voltage (Focusing Electrode)	1200 Volts dc
Grid No. 1 Voltage	
Negative Bias Value	140 Volts dc
Positive Bias Value	0 Volts dc
Positive Peak Value	2 Volts
Peak Heater-Cathode Voltage	
Heater Negative with Respect to Cathode	140 Volts
Heater Positive with Respect to Cathode	140 Volts
Altitude	70,000 Feet
Operating Temperature Range	—65 to +85°C

SYLVANIA ANNOUNCES

3 NEW TUBE TYPES WITH 9-T9 OUTLINE!

New **17HC8**, **6HC8** and **7695** offer important advantages inherent in the Sylvania unique 9-T9 design. Utilizing the straight-sided, 9-T9 bantam outline with its miniature 9-pin circle, these three types afford significant opportunities for compactness. The 9-T9 outline eliminates the octal base of the T9 and makes possible the use of tube structures capable of high plate dissipation in printed-circuit boards. This is accomplished with conventional 9-pin sockets widely used in printed circuits.

9-T9 increases volumetric efficiency of the chassis by eliminating the octal base of the T9 outline.

9-T9 enables the use of large tube-assemblies in those stages where higher power-dissipation capabilities of the tube are a design necessity to enhance reliability.

9-T9 maintains compactness of the equipment formerly afforded by tubes fitted with T6-½ header.

Sylvania 17HC8 is a triode-pentode designed for use as a vertical deflection oscillator and vertical deflection amplifier in 110° deflection circuits of TV receivers. Controlled for heater warm-up time, it is especially useful in 450mA series string operation. The pentode section has a plate dissipation of 11 watts. Structure of the 17HC8 includes an internal shield to reduce interaction of the elements. The 6HC8 is identical to the 17HC8 except for heater power requirements. In addition to normal 100% tests for shorts, continuity, plate current, gas, pentode screen current, heater cathode leakage, gm and triode cutoff, both types are tested 100% for peak plate and screen current, ratio of peak plate current to screen current, and microphonics.

Sylvania 7695, beam power pentode, features remarkably high power sensitivity as an audio frequency amplifier. In Class A1 operation, it can deliver 4.5 watts of power with a B+ voltage of only 130 volts. As a result, the 7695 makes possible economies in power supply requirements.

SYLVANIA 7695—Characteristics and Typical Operation

Class A1 Amplifier	Fixed Bias	Self Bias
Plate Voltage	130 Volts	140 Volts
Grid No. 2 Voltage	130 Volts	140 Volts
Grid No. 1 Voltage	—11 Volts	—
Cathode Resistor	—	100 Ohms
Peak AF Grid No. 1 Voltage (RMS)	11 Volts	8 Volts
Zero Signal Plate Current	95 mA	100 mA
Max. Signal Plate Current	100 mA	100 mA
Zero Signal Grid No. 2 Current	5 mA	5 mA
Max. Signal Grid No. 2 Current	13 mA	14 mA
Transconductance	11,000 μmhos	11,400 μmhos
Plate Resistance (approx.)	6,900 Ohms	6,800 Ohms
Load Resistance	1,100 Ohms	1,100 Ohms
Max. Signal Power Output	4.5	4.5
Total Harmonic Distortion (approx.)	11 Percent	11 Percent

17HC8
SYLVANIA
MADE IN U.S.A.

6HC8
SYLVANIA
MADE IN U.S.A.

7695
SYLVANIA
MADE IN U.S.A.

768
SYLVANIA
MADE IN U.S.A.

NEW HI-FI TYPE

SYLVANIA 7687

CONTROLLED FOR LOW HUM

The new 7687 is a 9-pin miniature triode-pentode controlled for hum, noise and microphonics. It's a hard worker in tone-control amplifiers, phase splitter and high-gain voltage amplifier circuits, yet it does its job without even "breathing audibly." Sylvania 7687 structure is rigidly mounted to reduce noise and microphonic effects. It features a cooler-operating cathode to assure low hum. Further assurance of low hum is provided by the use of a coil heater made of specially developed materials. The triode section has an equivalent hum and noise level of 7.5 microvolts, the pentode only 10.5 microvolts. Investigate the possibilities of a cooler-operating tube with unusually low hum and long life expectancy for your compact high-fidelity design. The Sylvania 7687 merits your interest.

SYLVANIA "GLEAM" PROJECT COMBATS TUBE CONTAMINANTS, INCREASES TUBE RELIABILITY

Project "Gleam" further increases Sylvania tube reliability by eliminating lint and dust particles in factory operations. Fifteen years ago, Sylvania took its first air-purification measures to reduce contaminants that can result in early-hour tube failure. "Gleam" has gained impetus until it now includes the use of air conditioning in factories, lint-free clothing, individual hooded work-tables, enclosed cloakrooms, methanol welding to eliminate splash particles, lint-free parts-containers, and specially processed getter material which resists flaking and spattering. Like many technological advancements, the "Gleam" Project will never be wholly complete. It is constantly undergoing change and improvement to maintain the Sylvania name for unsurpassed quality.

Electronic Tubes
Division of Sylvania
Electric Products Inc.
1740 Broadway, New York 19,
New York

SYLVANIA

Subsidiary of GENERAL TELEPHONE & ELECTRONICS

Whom and What to See at the Radio Engineering Show

(Continued from page 226A)

Deutsch Company, Electronic Components Div., Booth 1425
Banning, Calif.

Marve Mendelson, Martin Albert, Paul Szulborski, Jack Theriault, Joe Gunter, Donald R. Lea, Henry Comeau, Robert Summers, Roland Lawrence

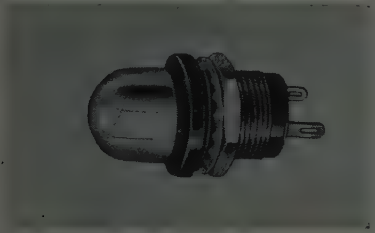
Advanced designs in miniature, environmental, electrical connectors for aircraft, rocket, missile and GSE applications. Hermetics, Insertable and Removable Contact Connectors, Cylindrical and Rectangular Rack-and-Panel Connectors, high performance resilient insert connectors—all will be shown along with application tools for crimping, insertion and removal of contacts.

Tobe Deutschmann Corp., Booths 2725-2727

See: Cornell-Dubilier Electric Corp.

Dialight Corp.
60 Stewart Ave.
Brooklyn 37, N.Y.
Booths 2829-2831

▲ R. E. Greene, M. Greene, H. W. Goodman, ▲ J. L. Weil, M. Roberts, R. B. King

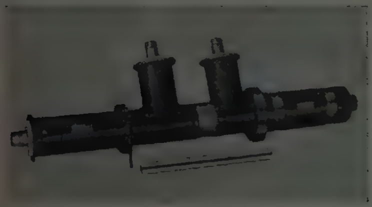


'' Sub-Miniature Pilot Light

New Sub-Miniature Pilot Lights, *Series 101-8430W, are water-tight on the face of the panel. Mount from FRONT of panel in 15/32" clearance hole. Accommodate T-1-¾ midget-flange-base incandescent lamps in voltages ranging from 1.3 to 28 volts. Also, *other new indicators, Datalites, etc.

Diamond Antenna & Microwave Corp.
River St.
Winchester, Mass.
Booths 1207-1209

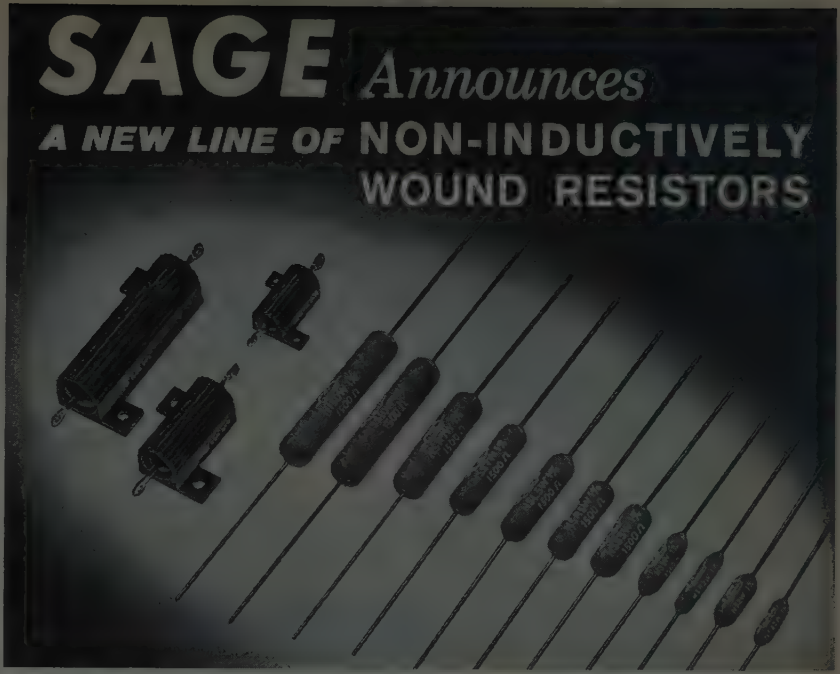
William L. Page, William Rand, ▲ Donald Brown, ▲ Donald Cozzens, ▲ Charles Cicciarella



Antennas, Multi Channel Rotary Joints*, Hi-Power Waveguide Rotary Joints*, High Power Coaxial Switches*, High Power RF Dummy Loads (Air Cooled)*, Low Loss Attenuators*, Diplexers, Directional Couplers, Frequency Meters, Hybrids, Phase Shifters, Waveguide & Coaxial Assemblies, Slotted Lines, Accessories.

(Continued on page 232A)

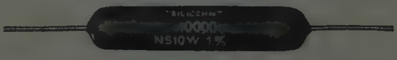
Elevators at north
and east sides
of the main lobby
take you direct to the
Fourth Floor



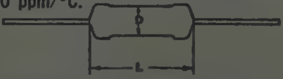
Sage "Silicohm" wirewound Resistors . . . outstanding and versatile Type "S" and chassis mount Type "M" are now matched by companion styles of non-inductively wound units. These resistors, designated Types "NS" and "NM," are designed for pulse or other radio frequency power circuits demanding negligible inductive reactance. They are precision made to rigid requirements of stability and reliable service life which Sage customers expect.

Check your requirements against these SAGE "Silicohm" Resistors

TYPE "NS" SILICONE COATED RESISTORS



Sage "Silicohm" Type "NS" units are compact, light weight. Exclusive insulation for extreme combinations of moisture and temperature environment (—65°C to 350°C) . . . dielectric strength—1000 volts RMS . . . precision to .05% . . . T.C. ±20 ppm/°C.

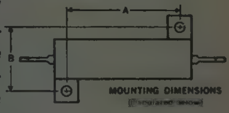


Style	ratings, WATTS	dimensions L	D
NSA2W	2	.500	.187
NSB2W	2	.812	.187
NS2W	2	.625	.250
NS3W	3	.750	.250
NSS5W	5	.875	.312
NSR5W	5	1.000	.312
NSL5W	5	1.125	.312
NSS7W	7	1.250	.312
NSR7W	8	1.375	.375
NSS10W	10	1.812	.375
NS10W	10	1.937	.375

TYPE "NM" METAL CLAD CHASSIS MOUNTED RESISTORS

SAGE "SILICOHM"
NM50W 512 .5%

Aluminum housed resistors for heat sink mounting, Type "NM" units feature considerably less heat rise than any other resistors of comparable size and wattage.



Lower hot spot means longer service life, near perfect stability—(Average resistance shift is only 0.4% after 1000 cycled hours at recommended loads), and exceptional reliability under extreme conditions. Dielectric strength: 1000 volts RMS to 2500 volts RMS, equal or exceeding Mil requirements . . . precision to .05%.

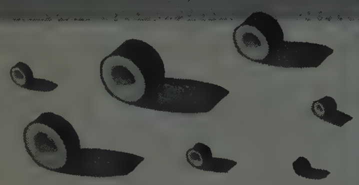
Style	ratings, WATTS	Nominal Mounting Dimensions, inches A	B
NM10W	10	.562	.625
NM25W	20	.719	.781
NM50W	40	1.562	.844

Write for samples and complete specifications.

SAGE ELECTRONICS CORPORATION
COUNTRY CLUB ROAD • EAST ROCHESTER, N. Y.

TOUGH

...AS A TURTLE'S BACK



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Whom and What to See at the Radio Engineering Show

(Continued from page 231A)

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Shreve, Ohio

▲ R. C. Mulligan, E. J. Rogers, ▲ Harry Halinton, ▲ Henry Lavin, William S. Mills, ▲ W. F. Satterthwaite, Howard Wadsworth, G. I. Schmidhammer

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Diehl Manufacturing Co., Booths 1819-1823

See: Singer Manufacturing Co.

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Digital Equipment Corporation
Maynard, Mass.
Booth 3831

▲ Kenneth H. Olsen, ▲ Harlan E. Anderson, ▲ Richard L. Best, John B. Brown, ▲ Jonathan Fadiman, ▲ Benjamin M. Gurley, Robert A. Hughes, Stanley C. Olsen, ▲ Walter E. Weeton

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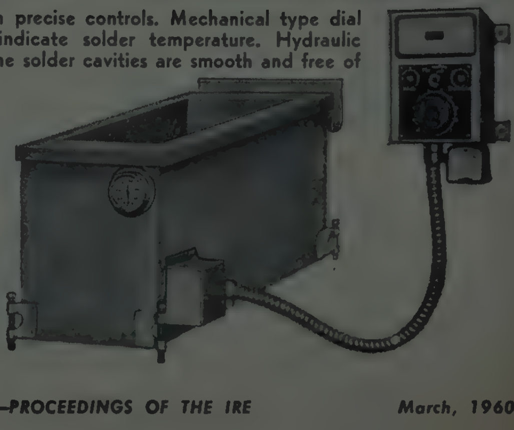

Dow Corning Corp., Booth 4501-4503
Midland, Mich.

R. Bloor, R. Dilger, D. Kauppi, S. Wooten, R. Spraetz, G. Swartzbaugh, L. Teichthesen, C. Christiansen, D. Christensen, M. Nakonechny, R. Naegele, W. Morgan, A. Smith, C. Currin

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See: Southwestern Industrial Electronics Co.

Wilbur B. Driver Co.
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(Continued on page 234A)

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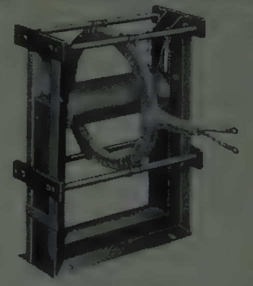

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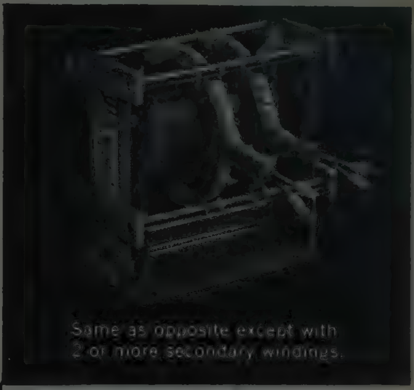
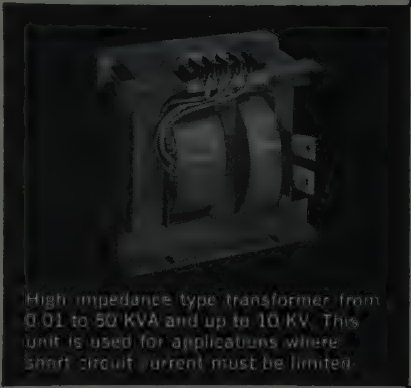


Same as opposite except with 2 or more secondary windings.



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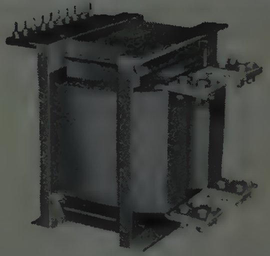
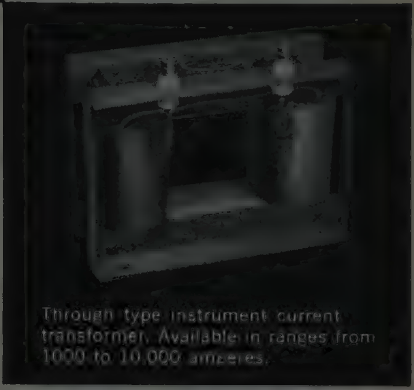


This transformer features low voltage high current secondary windings up to 4000 amps., and up to 300 KVA. Taps on the primary windings afford a wide range secondary current.



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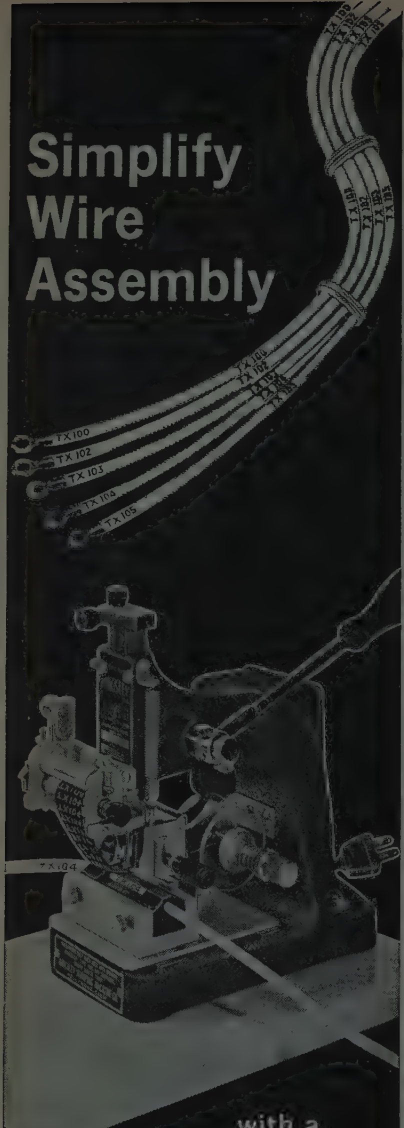

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(Continued from page 233A)

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(Continued on page 235A)

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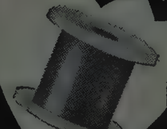

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(Continued from page 234A)

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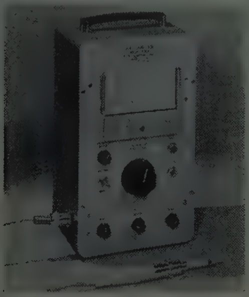

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(Continued on page 236A)

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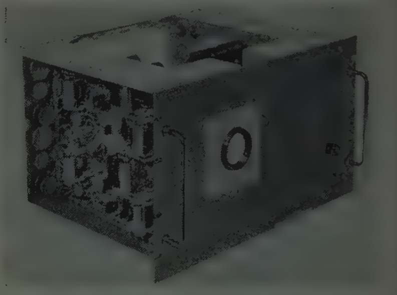

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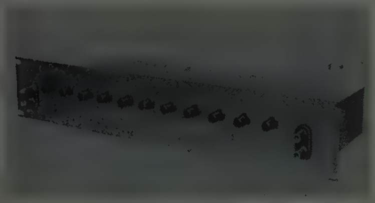

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Pressurization Units and Airborne Refrigeration Type Cooling Units for Electronic Equipment. Hydraulic Power Packs and Servo Mechanisms for Aircraft and Missiles. Pumps for Aircraft and Missiles. Servo Valves, Servo Systems, Actuators and Equalizer-Amplifiers.

(Continued on page 238A)

▲ Indicates IRE member.
* Indicates new product.

A complete listing of all registrants at the IRE National Convention and Radio Engineering Show, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

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105-125 V. AC.
50/60 CPS.
single phase

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10	TR30
15	TR40

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A new series of compact, budget-priced, laboratory power supplies, featuring uncompromising quality of materials and workmanship.

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- Regulation ±½% line & load.
- Zener Diode Reference.
- Ripple less than 5 M. V.
- Vacuum varnish impregnated magnetic components.
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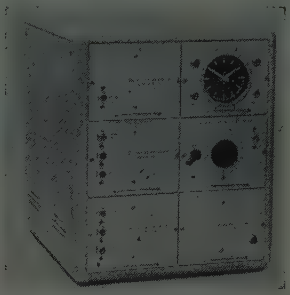
Whom and What to See at the Radio Engineering Show

(Continued from page 237A)

Ebauches S.A.

(Neuchatel, Switzerland)
c/o Freeport Engineering Co.
350 Fifth Ave.
New York 1, N.Y.
Booth 3947

Charles Friedman, A. Berger



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*New Model B-288 Quartz Clock Guaranteed Accuracy 1×10^{-7} for frequency standards, time keeping, high precision chronometry, also precision transistorized impulse units (Decade, Binary and 10 KC Oscillator) for computer and general circuit application. Full engineering data available on these & other Ebauches Test Equipment from Laboratories, Observatories, etc.

Ecco Electronic Components Corp., Booth M-20

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UHF Connectors, BNC Connectors, TNC Connectors, Type "N" and "C" Connectors, Telephone Plugs and Jacks, 125 Ohm Constant Impedance Connectors, Cable Assemblies.

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Boston 15, Mass.

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Instrument Division
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West Orange, N.J.
Booths 2739-2741

Victor W. Rose, Robert P. Zupa, George V. Boselli, Joseph C. Emma, John B. Norton, Arthur Douglas, Richard Thompson, Joseph Zercoe, Herbert F. Preiss, Edward J. Kerr

Model 323 R.F. Coaxial Cable

Servo motors, motor-generators and gearheads and electro-mechanical packages, time delay relays, thermostats and sensitive relays. Fire detection systems, oil pressure transmitters and indicators for aircraft and spacecraft. High temperature 1000°F R.F. coaxial cable; has excellent attenuation and low weight; this 50 ohm cable also excellent for use under nuclear radiation.

Eitel-McCullough, Inc.

301 Industrial Way
San Carlos, Calif.
Booths 2410-2412

Fred Johnstone, Hal Yokela, Cliff Warner, Bob Plummer, Al Melrose, Dave Wyand, Berk Baker

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Elastic Stop Nut Corp. of America, Booth 2343

See: A'G'A Division.

Elco Corp.

"M" St. below Erie Ave.
Philadelphia 29, Pa.
Booth 1515

▲ Benjamin Fox, Leo Kagan, ▲ H. E. Ruehlemann, ▲ Samuel Weiss

Series 8105 Varicon Connector

Series 8007-8008 Rack-and-Panel or Cable Connectors. Series 8007, with screw actuation: 75, 100, 130 contacts. Series 8008, without screw actuation: 80, 95, 110, 125, 140 contacts. Both Series available with or without cover. Feature Varicon contacts. *New micro-miniature connector Series.

Eldico Electronics Div., Booths 1202, 1301-1303

See: Radio Engineering Laboratories, Inc.

Electra Manufacturing Co., Booths 2834-2836

4051 Broadway
Kansas City 11, Mo.

Gordon Groth, W. E. McLean, R. T. Means, A. B. Mayer, R. R. Burton

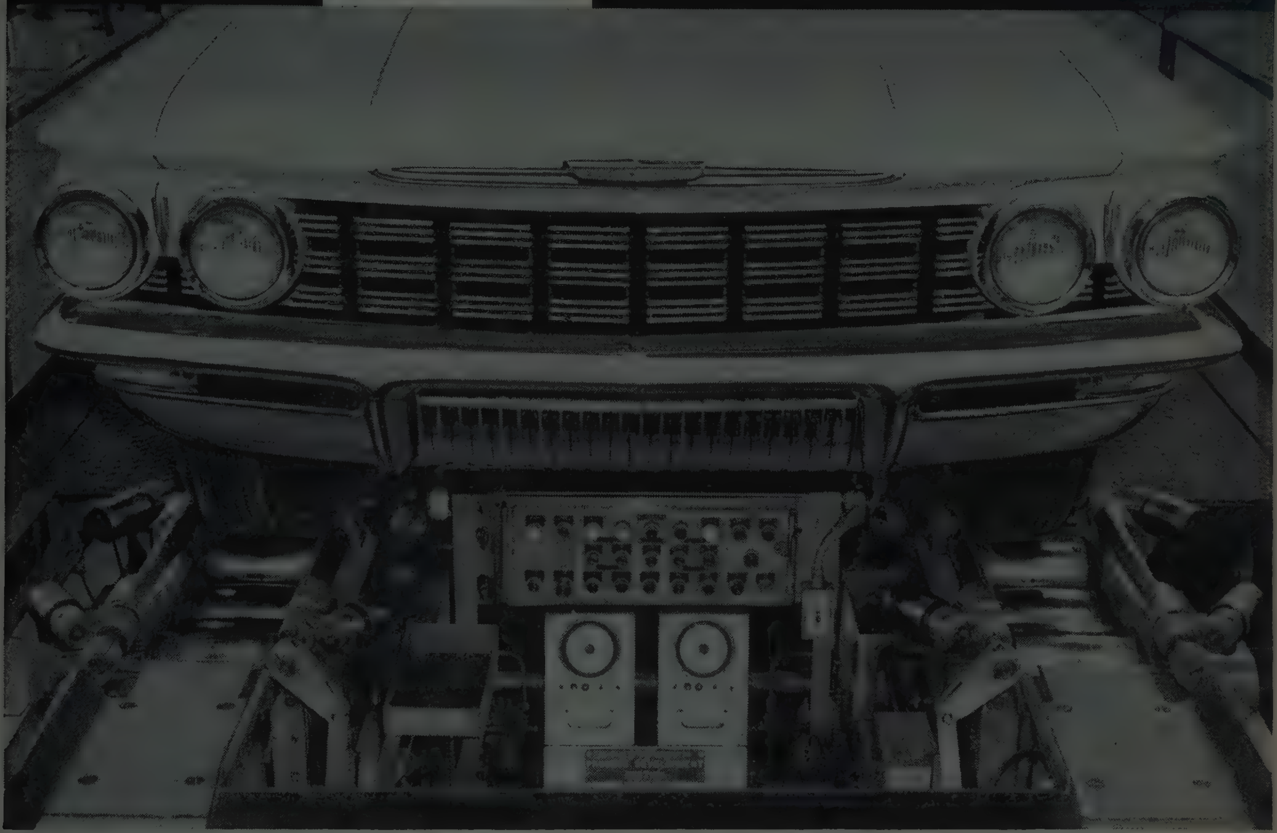
Precision Film Resistors, Deposited Carbon, Metal Film and High Temperature, as well as a complete line of Ceramic Disc and Plate Capacitors.

(Continued on page 240A)

Your firm not listed?

If you would like to become an exhibitor in the 1961 show, write for information to IRE Exhibits Dept., 72 W. 45th St., New York 36.

The Inquiring Mind at Oldsmobile



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Whom and What to See at the Radio Engineering Show

(Continued from page 238A)

Electralab Printed Electronics Corp.
Needham Heights 94, Mass.
Booth 2130

▲ Warren G. Abbott, ▲ Richard G. Zens, George McCarthy, Burt M. Isaacson, H. Eugene Jones

Printed Wiring; Printed Circuit Assemblies; Cu-Con Plated Holes; Exclusively for High Reliability Electronics. *Flush Circuits with Cu-Con Plated Holes. *Protowiring Dept. Services Rush Requirements for Pilot Runs. Protomaka, the "Do-it-Yourself" Laboratory Unit for Processing of Printed Wiring Boards.

Electric Auto-Lite Co., Booth 4520
Champlain St.
Toledo 1, Ohio

S. T. Rose, V. R. Steinmeyer, S. W. Weidenbach, R. Twells, G. Rinebold

Wire & Cable, Instruments, Ceramics.

Electric Hotpack Co., Inc.
5019 Cottman Ave., Dept. #761
Philadelphia 35, Pa.
Booths 3931-3933

Arnold Mann, Tom White, Ira McFarland, Bart Conchar, Douglas Bergen, Len Wingard, William Rariden, Morton Levy

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Controlled Temperature & Humidity Chambers: Hot-Cold Test Chambers*, —100°F. to 400°F.; Walk-in Rooms, 0°C. to 40°C., ambient to 98% R.H.; Ovens, 35°C. to 100°C., 0°C. to 100°C., 20% to 98% R.H.; Vacuum Ovens, ambient to 200° and 300°C., vacuum to 1 Micron. For testing, conditioning and processing electronic components.

Electrical Industries
Division of Philips Electronics & Pharmaceutical Industries Corp.
Murray Hill, N.J.
Booths 2526-2528

O. H. Brewster, P. A. Muto, K. F. Mayers, J. Jonassen, D. Wilson, C. W. Beach

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New expanded line of Compression Type Threaded End Seals. Glass-to-Metal Seals. Complete line standard terminals, threaded seals, transistor and other miniature closures. Custom seals to specifications, and custom sealing of components.

(Continued on page 241A)

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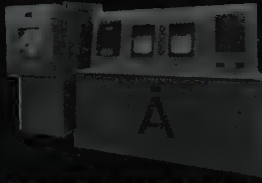
The quality line of Environmental Chambers and Test Equipment



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Descriptive Data Sheets Available on all test equipment

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Telephone CApital 6-7407

Whom and What to See at the Radio Engineering Show

(Continued from page 240A)

Electro Devices Inc., Booth 4107
580 Main St.
Wilmington, Mass.

Paul J. Post, Fred F. Cain, A. Allyn Ryalls, Edw. Gratto

Manufacturing Toroidal Coil Winders for Production (Model D6) and Laboratory (Model C). Core range 2″ O.D. to 1/16″ I.D. Wire 24AWG—46AWG—Speed 1000 Turns pm.

Electro Instruments, Inc.
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Booths 3836-3838

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All Electronic Analog-Digital and Digital-Analog Converters; Digital Voltmeters, Ratiometers, Ohmmeters; Wide-band Transistorized Single-Ended or Differential DC Amplifiers; Solid State X-Y Recorders and Accessories; Transistorized Counters and Timers; Counter Systems; Data Acquisition Processing and Recording Systems.

Electro-Measurements, Inc., Booths 3010-3011
See: Electro Scientific Industries, Inc.

Electro-Mec Laboratory, Inc.
47-51 33rd St.
Long Island City 1, N.Y.
Booth 2312

▲ Forbes Morse, ▲ Robert Wiener, Bob Bordewieck, ▲ Phil Luce, Carl Bernsten, Bob Ebert, George Boziwick, Gil Bassin, Dann Neubauer, Ellis C. Scovel, Jerry Bouton, Perc Ridley

5
4
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7

Electro-Mec Type D3OU-10 DIGITOMETER®

Potentiometers—Variable, Wirewound, Precision, Ultra Low Torque; Digitometers® (Analog to Digital Converters); Goniometers (For Measuring and Testing of Potentiometers, Synchros and Similar Rotary Electronic Components); Servomechanisms, For Industrial and Military Aircraft Control Problems.

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Perkasie, Pa.

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Ammeters, voltmeters and milliammeters, 2 inches to 4½ inches. Instrument type miniature relays. Miniature flag type circuit indicators. Microammeters. Tuning meters.

(Continued on page 242A)

Be sure to
see all four floors!

---

1. $z = f(x,y)$ 2. $z = f[g(x), h(y)]$ 3. $z = f(u \cdot x, v \cdot y)$

4. $y_1 = f_1(x),\ y_2 = f_1(x), ---- y_{20} = f_{20}(x)$

5. $z_1 = f_1(x,y), ---- z_4 = f_4(x,y)$ 6. $u = z \cdot f(x,y)$

7. [illegible]

NOW...A NEW APPROACH TO FUNCTION GENERATION

The Link Analog Function Generator

Link's analog function generator offers a new level of performance for analog computation and simulation. Key to this outstanding performance... a Link-developed *rectilinear servo motor* with solid-state servo-amplifiers and *a ceramic-film resistance element.*

This new function generator eliminates the high drift and complex design of diodes generators, provides high-speed operation without the limited flexibility of optical techniques and the inherent backlash, friction and inertia problems of existing servo generators.

IT PROVIDES:

RELIABILITY— Modular design • Automatic failure protection • Simplified maintenance

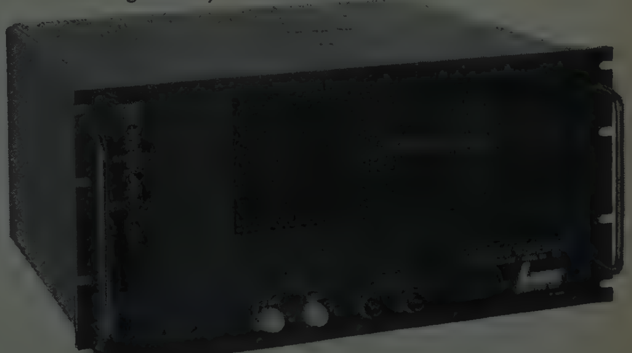
ECONOMY— Standardized components • Printed circuits

FLEXIBILITY— Plug board programming • Rack mounted or table top use

VERSATILITY— Numerous functions or function groups can be generated with minor modification, or by connecting one or more generators in series.

The analog function generator, first of a line of DIALOG* components and system building blocks to be introduced by Link, is another example of Link's unique computer capability. Thoroughly experienced in analog and digital techniques, Link can provide the most objective, economic solution to computation, simulation and control problems. For additional information on Link's new Function Generator or its broad computer capabilities — and your copy of Link's DIALOG* catalog — write to Industrial Sales Department.

DIALOG* (Link Digital-Analog System Components and Building Blocks)



***DIALOG is a Trademark of Link Division, General Precision, Inc.**

LINK DIVISION
GENERAL PRECISION INC.
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TRANSISTORIZED
D-855
GAUSSMETER

- Complete portability for use in field or lab
- Reads flux fields up to 30,000 gauss
- Can be equipped to read Earth's field flux density
- Probe is only .025″ thick
- Active area of probe .01 square inches
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- Power Supply: selective from 105-125 volt 50-60 cycle line or internal batteries
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- Overall size: 13-1/2″ high, 8-3/4″ wide, 7-1/4″ deep

Precision built, completely transistorized, the new D-855 Gaussmeter accurately measures flux density and determines "flow" direction. Ideal for measuring and locating "stray fields", plotting variations in strength and checking production lots against a standard. It's simple to operate. The Dyna D-855 doesn't require jerk or pull, gives no ballistic reading. Can be operated in the field with batteries which are enclosed in rugged protective carry case. This is an improved version of the pioneering D-79 Gaussmeter (Pat. #2,707,769) which has modernized magnetic flux measurement for the past six (6) years.

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BOOTH 1917

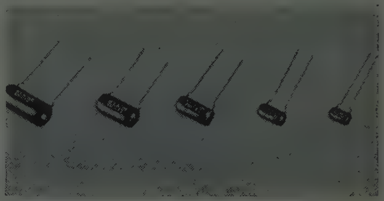
DYNA-EMPIRE INC.
1075 STEWART AVE. GARDEN CITY N. Y.
Pioneer 1-2700

Whom and What to See at the Radio Engineering Show

(Continued from page 241A)

Electro Motive Mfg. Co., Inc.
South Park & John St.
Willimantic, Conn.
Booth 2734

J. Kevin Foley, Milton Lauter, ▲ Arthur W. Evans, Joseph Regan, James Gilligan, Charles Rueb, Peter Nichols, Howard Ogushwitz, John Obsharsky, John Haines



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Electro-Pulse, Inc.
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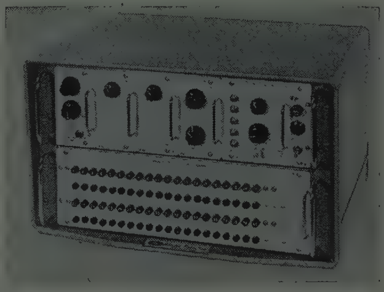
Culver City, Calif.
Booths 3810-3812

▲ James S. Johnson, ▲ J. E. Niebuhr, Bernard Evans



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Affiliated Servo Corp. of America. General Purpose Pulse Generators, Digital Pulse Generators, Current Generators and Core Testers, Time Mark Generators, Electronic Counters, Word Generators.

Electro Scientific Industries, Inc.
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Booths 3010-3011

▲ Douglas Strain, James Kirwan, Bill Lyon, ▲ Jack Riley, Paul Lintner, Norman Morrison, Lloyd Smith

Impedance Bridges and accessories, Resistive and transformer type voltage dividers, Decade resistors, Decade capacitors, Esiac computer and special products.

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Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

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Booth 1929

George J. Pandapas, Arthur Asch, Eugene Parks, P. J. Marshall, William Kennedy, Robert Kinsey, Robert Leslie, Herbert Gross, Peter Filipczak, William Thacker, George Merker, Richard Koester

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Electro-Voice, Inc., Booth 1632
Cecil & Carroll Sts.
Buchanan, Mich.

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Microphones, Cartridges.

Electrocraft, Inc., Booth 2126
See: G-C Electronics Mfg. Co.

Electrol, Inc., Booth 3940
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R. A. Sinker, D. H. Sinker

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▲ Mort Zimmerman, Mike Ling, Sol Cornberg, Irving Presser

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▲ Vincent J. Skee, Harry N. Reizes, John Costello, Richard Wiggins, Truus M. Skee

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Electronic Associates, Inc.
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Long Branch, N.J.
Booths 3712-3718

R. L. Yeager, W. F. Blodgett, J. H. Smiley, J. D. Kennedy, B. Johnson, O. J. Sullivan, J. E. McCloskey, W. Peet, R. J. Doelger, W. O'Brien, A. T. Ashton

231R PACE Analog Computer

231R PACE Analog Computer, high speed repetitive operation, digital programming equipment (ADIOS), X-Y analog and digital plotters (VARIPLOTTER, DATAPLOTTER), Desk-top analog computer (PACE TR-10), analog-digital and digital-analog computer linkage system (ADDALINK), analog computer package for process control.

(Continued on page 244A)

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(TUNNEL DIODE)

INVENTED BY

Dr. ESAKI

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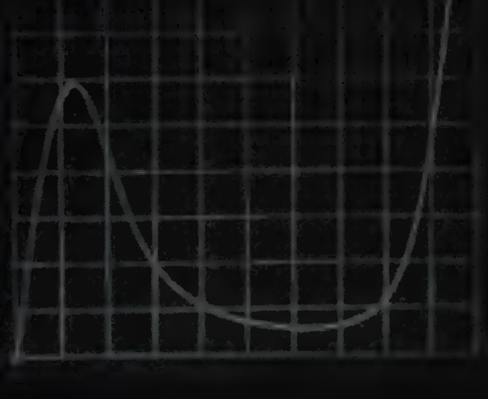

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Whom and What to See at the Radio Engineering Show

(Continued from page 242A)

Electronic Daily, Booths 4404-4406
See: Hayden Publishing Co.

Electronic Design, Booths 4404-4406
See: Hayden Publishing Co.

Electronic Industries, Booths 4301-4303
Chestnut & 56th Sts.
Philadelphia 39, Pa.

Robert E. McKenna, ▲ Creighton M. Marcott, ▲ John E. Hickey, Jr., Elmer Dalton, Joseph Drucker, ▲ Menard Doswell, Shelby A. McMillion, B. Wesley Olson, ▲ Bernard F. Osbahr, ▲ Richard G. Stranix, ▲ Christopher Celent, Donald J. Moran, Gerald B. Pelissier, George Felt

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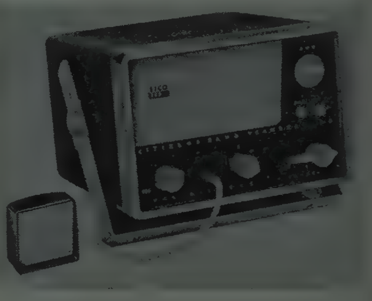
Long Island City 1, N.Y.
Booth 3505

Harry R. Ashley, Philip A. Portnoy, Mel Fink, Richard Dugot, Robert Clark Duff, Ike Rosenstein, Mannie Horowitz, Vince Proc, Kaz Komendowski



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Booths 2213-2215

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Electronic News, Booths 4419-4421

See: Fairchild Publications, Inc.

Electronic Representatives Association, ERA Room 319
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Electronics International Co., Booth 3018

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Electrosnap Switch Division
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(Continued on page 246A)

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SERIES
670

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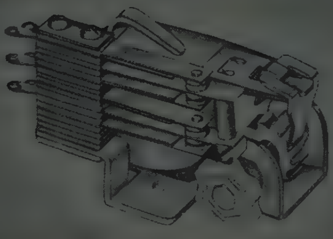

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I.R.E. Show

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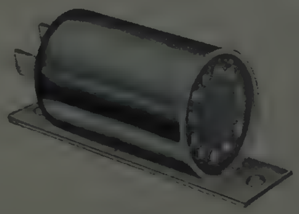

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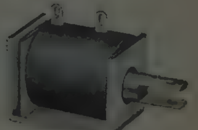

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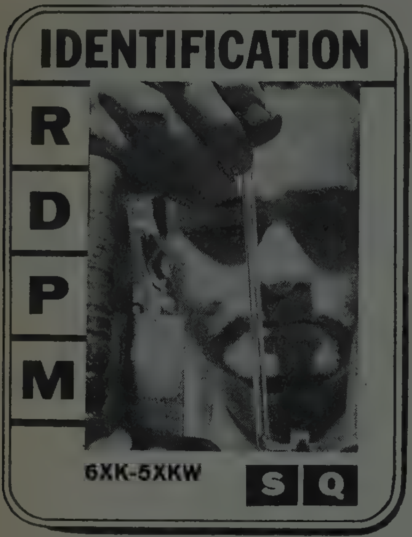

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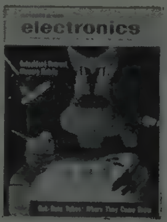

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Whom and What to See at the Radio Engineering Show

(Continued from page 245A)

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Elgin, Ill.
Booths 4420-4424

▲ James Wells, Sr., ▲ Herb Golz, ▲ Larry Fay, William Wells, Harold Bowen, Michael Votava, James Wells, Jr.

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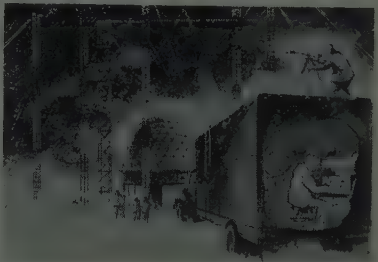
Empire Devices Products Corp.

37 Prospect St.
Amsterdam, N.Y.
Booth 3818-3820

▲ Michael T. Harges, ▲ Joseph Lorch, ▲ William S. Lambdin, W. Leo Bain, Jr.



*Noise & Field Intensity Meters, 14 KC to 10 KMC; Power Density Meter; *Coaxial Crystal Mixers; *Microwave Attenuators; Terminations; Microwave Power Attenuators; Microwave Attenuator Panels; *Microwave Step Attenuators; *Ultra-Sensitive Receiver; Radar Interference Blanker; Variable Frequency Power Supplies; Microwave Impulse Generators; AM Modulation Meter.

▲ Indicates IRE member.
* Indicates new product.

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Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

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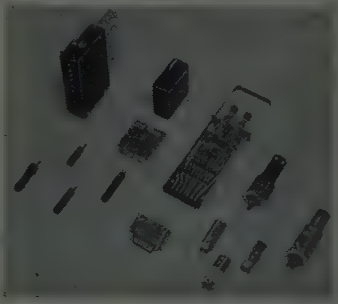

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(Continued on page 248A)

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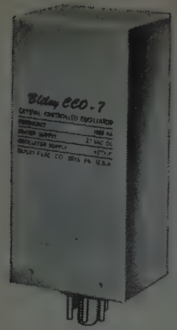

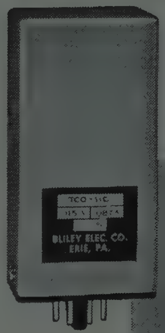

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STABILITY: ±.2 ppm

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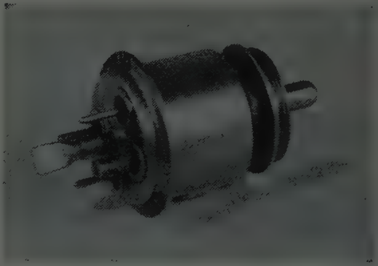
Whom and What to See at the Radio Engineering Show

(Continued from page 246A)

Ercona Corp., Booth 2706
See: Belling & Lee, Ltd.

Ericsson Corp.
100 Park Ave.
New York 17, N.Y.
Booth 2238

Larry Farrar, George Schindler, Nicholas J. De Salvo, Irwin Feinstein, Phil Diamond, Sigvard Tomner, Gary Balsam, Sam Flax



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See: The Ericsson Corp. & North Electric Co. Subsidiaries.

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Booth 3243

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ESC Corporation, Booth 2915
See: ESC Corp. alphabetical listing, page 237A.

Eubanks Engineering Company, Booth 4043
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Pasadena, Calif.

E. F. Eubanks, L. R. Barrett, Dudley Bell, Jerry Maloney, Murray Salit

Model 810 Automatic Wire Cutter & Stripper Capable of Cutting and Stripping Wire From 1 Inch to 300 Feet Long. Offers Quick Set-Up Changes, High Speed Operation. Model 300 Automatic Wire Prefeed For Use With Automatic Wire Strippers.

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(Continued on page 250A)

▲ Indicates IRE member.
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SUPER HIGH-SPEED SWITCHING TRANSISTORS TYPE 2N501

	Typical	Maximum	Units
Rise Time (t_r)	9	18	mμsec
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Fall Time (t_f)	7	10	mμsec

In circuit with current gain of 10 and voltage turnoff.

Also available as special type 2N501A for 100° C. maximum storage and junction temperatures.

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Type 2N501 Transistors are available from Sprague now at extremely reasonable prices. They are transistors you can use today! You need not delay your development work for the future when you design high-speed switching circuits with Type 2N501 Micro-Alloy Diffused-Base Transistors.

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* *Sprague micro-alloy, micro-alloy diffused-base, and surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable.*

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Whom and What to See at the Radio Engineering Show

(Continued from page 248A)

FXR, Inc.
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Woodside 77, N.Y.
Booths 3713-3717**

▲H. Feldmann, ▲T. N. Anderson, W. D. Marshall, ▲J. Ebert, C. T. Zavales, ▲N. Deoul, ▲M. Magid, ▲L. Bertan, R. Diamond, ▲J. R. O'Donnell

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Fairchild Camera & Instrument Corp., Defense Products Div., Booths 2701-2707
**Robbins Lane
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Booths 2701-2707**

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Fairchild Semiconductor Corp.
**Subsid. Fairchild
Camera & Instrument
Corp.
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Booths 2701-2707**

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**Falstrom Court
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Booths 4315-4317**

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(Continued on page 252A)

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WIDE RANGE MODELS

MODEL NUMBER	D-C OUTPUT	
	VOLTS	AMPS
T060-15	0-60	0-15
T036-30	0-35	0-30
T032-30	0-32	0-30
T014-30	0-14	0-30
T07-30	0-7	0-30

Brief Specifications (all models)

REGULATION, LINE OR LOAD: 0.03% or 0.01 V (0.01% or 0.003 V available).

RIPPLE: Less than 1 millivolt rms.

CIRCUIT PROTECTION: (1) electronic circuit breaker plus (2) electromagnetic circuit breaker plus (3) input line fused.

NARROW RANGE MODELS ALSO AVAILABLE

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Whom and What to See at the Radio Engineering Show

(Continued from page 250A)

Fansteel Metallurgical Corp.
North Chicago, Illinois
Booths 4021-4022

▲ H. Paul Weirich, J. W. Rose, R. Jaeger, G. Iaggi, W. Bullock, R. Fieldman, C. Blanchard, G. Cook, H. Douglas

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Coated tungsten filaments for vacuum tubes; Stranded Tungsten Coils for vacuum metallizing; Iron cores and waveguide attenuators for radio and radar. A development program is under way to produce plastic film and solid electrolyte tantalum capacitors.

Federal Electric Corp., Booths 2510-2520, 2615-2625
See: International Telephone & Telegraph Corp.

Federal Pacific Electric Co., Booths 2725-2727
See: Cornell-Dubilier Electric Corp.

Federal Pacific Electric Co., Booth 2338
See: Fifty Avenue L, Inc.

Federal Shock Mount Corp., Booth 1324
See: Korfund Co., Federal Div.

Federal Tool Engineering Co.
1384 Pompton Ave.
Cedar Grove, N.J.
Booth 4428

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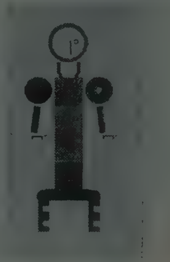

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Various types of indicating instruments, switches, and precision balances.

(Continued on page 254A)

▲ Indicates IRE member.
* Indicates new product.

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4-millimicrosec silicon mesa computer diodes

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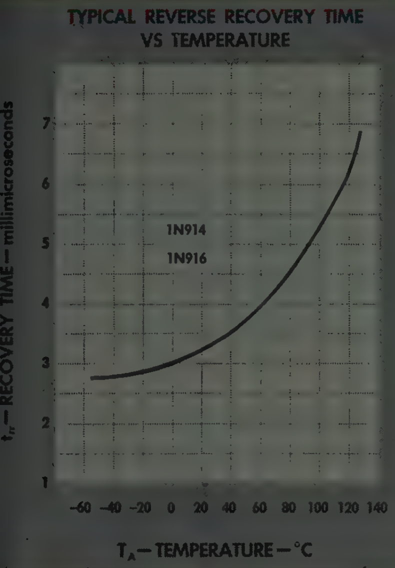
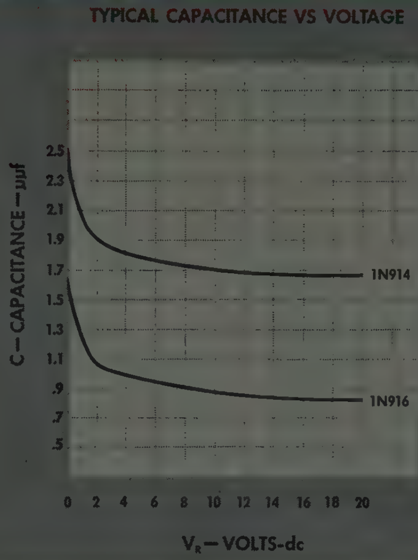
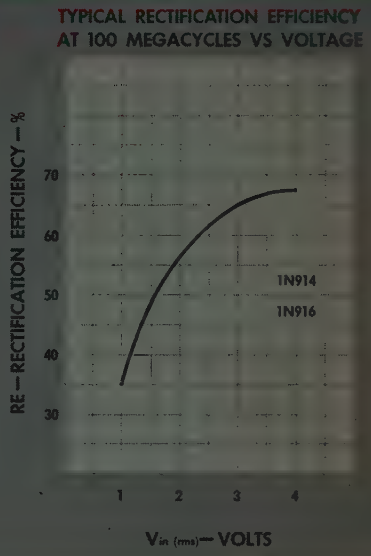

TYPICAL REVERSE RECOVERY TIME VS TEMPERATURE


TYPICAL CAPACITANCE VS VOLTAGE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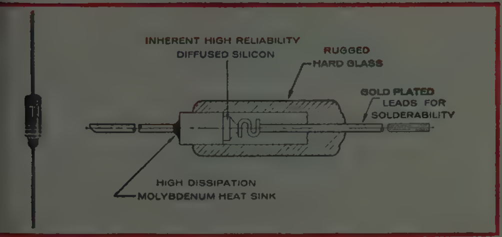
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TI

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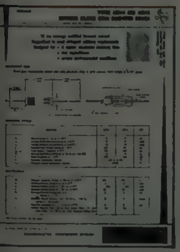
*10-ma forward, 6-v reverse, recover to 1-ma reverse



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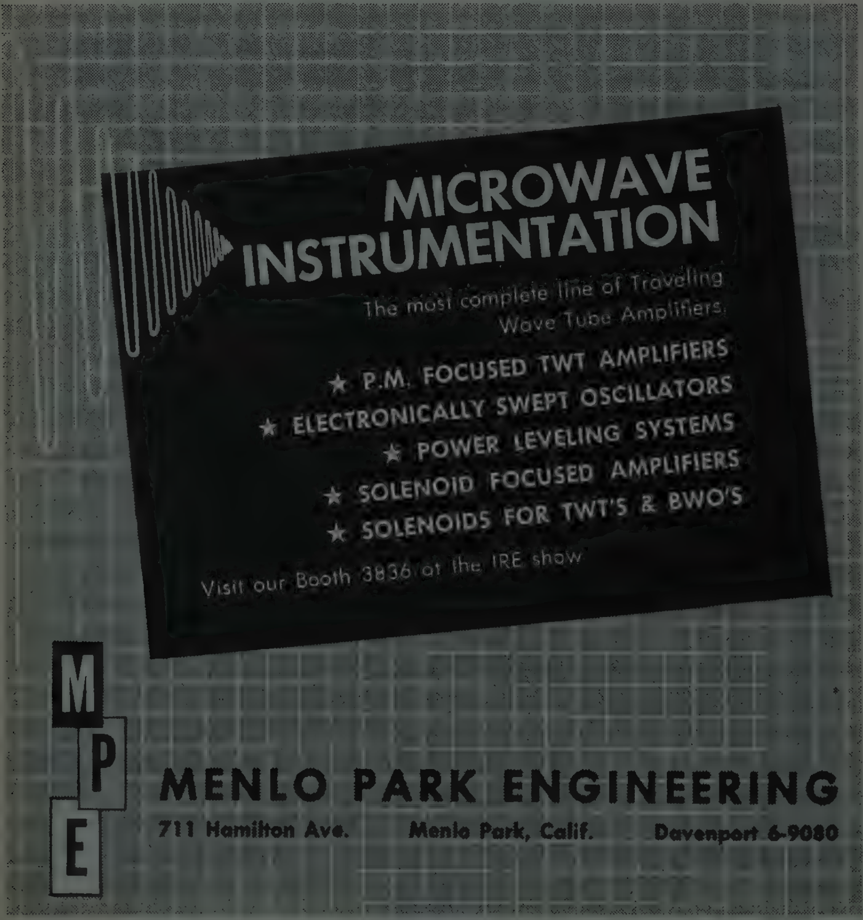

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Whom and What to See at the Radio Engineering Show

(Continued from page 255A)

G-L Electronics Co., Inc., Booth 1916
2921 Admiral Wilson Blvd.
Camden 5, N.J.

Stephen G. Lax, Norman E. Williams, ▲ Charles H. Fritz, James R. Jaquet, Boyd F. Beatty, Frank Hayes

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GOE Engineering Co., Booth 4053
P.O. Box 22004
219 S. Mednik Ave.
Los Angeles 22, Calif.

▲ Mel Terkla, Robert Relly, ▲ Arvin Bell, ▲ Sonny Simberkoff, Jack Simberkoff, Art Stangel, Harry Lewis, Art Golenpaul, Mike Oberst

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GPL Division, General Precision, Inc., Booth 1505
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Pleasantville, N.Y.

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Gabriel Electronics Div., The Gabriel Co., Booths 1720-1722
135 Crescent Rd.
Needham Heights 94, Mass.

▲ Samuel W. Stewart, ▲ Allan W. Jayne, Edward S. Prohaska, Joseph L. Buckley, ▲ Jack B. Hamre, Robert F. Stewart, Bruno Pawlowski, Louis Lamperti, J. Thomas Curran

*New 4000 MC Point-To-Point Feed for 6, 8, & 10 foot Parabolic Antennas. 28 foot Beacon Antenna ATCBI on 19 foot diameter ASR-4 Airport Surveillance Radar Antenna—Other features—Omnibus of Rotary Couplers, Single, Dual & Multi-Channel—High Power—Low VSWR: AT-781A/U Circular Polarized Shipborne Drone Command Antenna.

Gamewell Company, Potentiometer Div., Booth 2838
1238 Chestnut St.
Newton Upper Falls 64, Mass.

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Potentiometers and miniature metal housed items, including trimmer, precision, differential, multiturn Rotary Switch, and other special potentiometers.

(Continued on page 258A)

First and Second floors—Components
Third floor—Instruments and Complete Eqiupment
Fourth floor—Materials, Services, Machinery

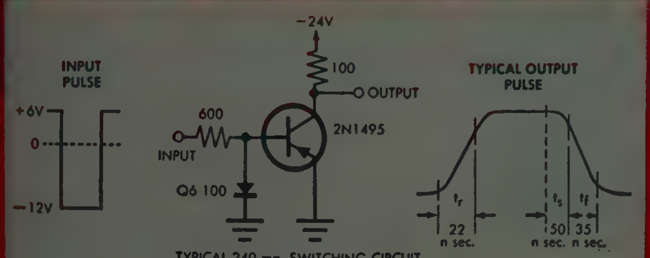
PHILCO ANNOUNCES

THE FASTEST HIGH-CURRENT SWITCHING TRANSISTORS!

MADT*

2N1495 · 2N1496
2N1204 · 2N1494

These Diffused-base Transistors are capable of utilizing the full speed of new magnetic film memory planes



TYPICAL 240 ma SWITCHING CIRCUIT
WITH TURN ON CURRENT OF 20 ma
AND TURN OFF CURRENT OF 10 ma

TYPICAL CHARACTERISTICS

TYPE	CASE	P_T @25°amb. (Max)	V_{CES} (Max)	V_{CE}(SAT)	V_{BE}	h_{FE}	f_T
				$I_C = -200$ma $I_B = -10$ma		$V_{CE} = -1$v $I_C = -200$ma	$V_{CE} = -10$v $I_E = 25$ma
2N1495	TO-9	250mw	−30v	0.35v	0.60v	60	320mc
2N1496	TO-31	*0.5w	−30v	0.35v	0.60v	60	320mc
2N1204	TO-9	250mw	−20v	0.35v	0.60v	60	320mc
2N1494	TO-31	*0.5w	−20v	0.35v	0.60v	60	320mc

*At 25°C case temp.

These new Philco MADTs are the result of a revolutionary new development of the Precision-Etch process, which gives high switching speed at high currents. *They are capable of switching 400 milliamperes of current at a 10 mc clock-rate* . . . and are the only transistors available today that permit full utilization of high-speed magnetic film memory planes. The typical f_T of 120 mc at 100 ma makes these units particularly suitable for video drivers, pulse line drivers and other high-current switching circuits. The ultra high-frequency response at the levels normally encountered in current-switching logic circuits, coupled with high dissipation capabilities, makes these units desirable for this class of circuit application.

Both the 2N1495 and 2N1204 are available in studded versions for higher power applications. Typical characteristics are shown in the accompanying table. For complete application data, write Dept. IR-360.

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MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

Whom and What to See at the Radio Engineering Show

(Continued from page 256A)

Gardner-Denver Company, "Wire-Wrap" Division, Booth 4530
Grand Haven, Mich.

H. F. Wilson, G. W. Roth, W. Long, E. Julander, W. N. Christiansen, W. F. Bigony, E. L. Keating, R. Van Schelven, C. F. Allen, P. Meaden, B. V. Hayes, R. E. Shute, G. P. Sheldon, P. Swayze, J. W. Kaar, G. R. Dana

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Garlock Electronic Products, The Garlock Packing Co., Booths 2814-2816
Camden, N.J. and Palmyra, N.Y.

▲ John P. Dearie, Richard Graeff, Frederick O. Dutton, Harry S. Stott, ▲ Parker Naudain, ▲ Karl Bohaker, Joseph Stewart, George Hawkins, Peter Woodams, Bern Kalp, Wayne Underwood, Joseph Burgin, T. L. Denney, R. A. Lyons

CHEMELEC high voltage miniature, subminiature feed-through and stand-off insulators, connectors, subminiature tube and transistor sockets, subminiature tube and transistor lead insulators, tube sockets, grommets, plastic stock shapes and intricate shapes, inserts, thin sections, threaded parts to precision tolerances are available in Teflon, T.F.E., F.E.P., Kel-F, Nylon, Delrin. Teflon Spaghetti. Copper Clad Teflon.

Garrett Corp., Booth 3926
9851-9951 Sepulveda Blvd.
Los Angeles 45, Calif.

R. Dale Moyer, Richard Callison, Karl Granlund, Peter Depp, Hilliard Davis, Charles Baugh, Gerald Rennerts

Infra-Red Cooling Equipment; Electronic Cooling Units; Fans; Temperature Controls; Air Data Computer Systems; Electrical Motors, Actuators & Generators; For Aircraft & Missile Applications.

Gates Radio Co., Booth 3515-3517
123 Hampshire St.
Quincy, Ill.

Larry Cervone, Abe Jacobwitz, Bud Ayer, Bob Hallenbeck, Don Udey

Radio Broadcast equipment for AM, FM, TV, communications transmitters and associated equipment.

General Aniline & Film Corp., Booth 4133

See: Ozalid Division.

General Cement Manufacturing Co., Booth 2126

See: G-C Electronics Mfg. Co.

(Continued on page 260A)

▲ Indicates IRE member.
* Indicates new product.

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KARMA High Resistance Alloy
THERLO Glass Sealing Alloy

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D-H vacuum melting produces alloys of higher ductility and tensile properties. These are achieved by greatly reducing inclusions, especially oxides and nitrides. Other direct benefits are elimination of gas, not only from the surface but from the entire mass, and general improvement in the electrical, electronic and mechanical properties to meet critical specifications.

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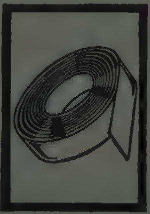

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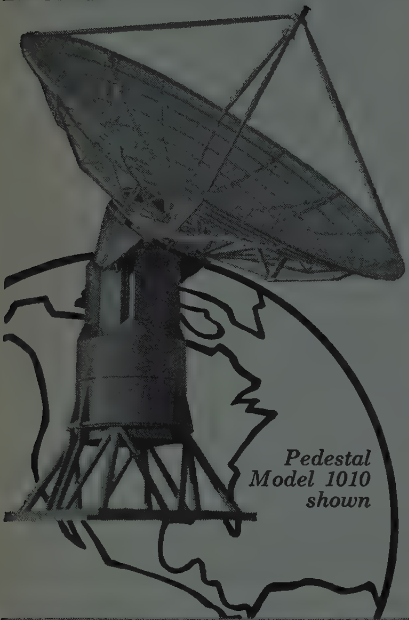

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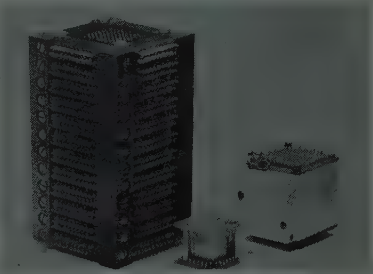
Whom and What to See at the Radio Engineering Show

(Continued from page 258A)

General Ceramics Div.
Indiana General Corporation
Crows Mill Rd.
Keasbey, N.J.
Booths 1310-1312
J. P. Manley, C. L. Snyder, J. W. Schallerer, R. E. Warren, N. Shapiro, H. Landsberger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General Chemical Div., Booth 4216
See: Allied Chemical Corp.

General Dynamics Corp.
Liquid Carbonic Division
135 South La Salle St.
Chicago 3, Ill.

Booth 3060

C. B. Brisendene

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General Electric Company, Capacitor Department, Booth 2928
Hudson Falls, N.Y.
F. R. Flood, J. P. Holloway, F. L. Johnson, ▲ W. H. Roberts, D. F. Schmidt, J. G. Hanan, W. C. Bakes, J. Feininger, G. F. Wallin

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(Continued on page 262A)

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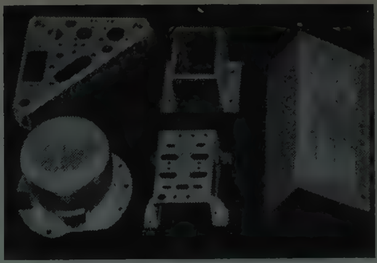
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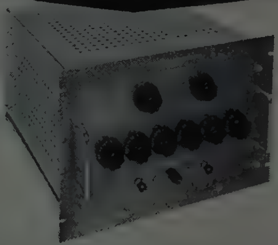
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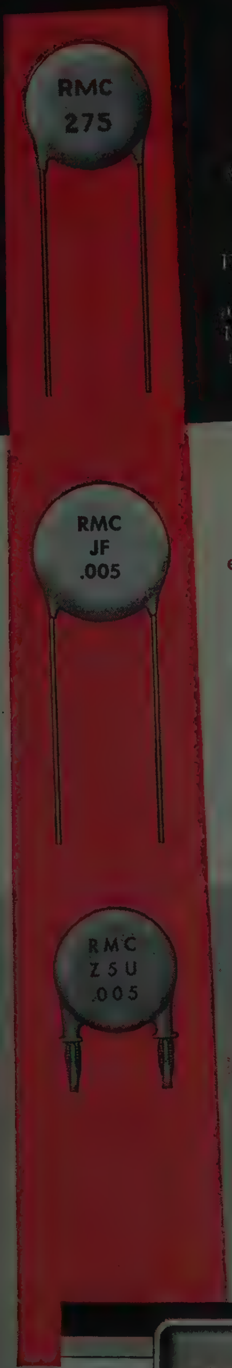

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temperature compensating DISCAPS meet and exceed the specifications of EIA RS-198. Featuring greater dielectric strength Type C DISCAPS are ideal for VHF and UHF applications. Rated at 1000 working volts for a higher safety factor.

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DISCAPS are designed for by-passing, coupling or filtering applications and they meet and exceed EIA RS-198 specifications for Z5U capacitors. Type B DISCAPS are available in capacities between .00015 and .04 MFD with a rating of 1000 volts.

TYPE JF

DISCAPS are engineered to exhibit a frequency stability characteristic that is superior to similar types. These DISCAPS extend the available capacity range of the EIA Z5F ceramic capacitor between +10°C and +85°C.

TYPE JL

DISCAPS should be specified in applications requiring a minimum of capacity change as temperature varies between −60°C and +110°C. Over this range the capacity change is only ±7.5% of capacity at 25°C. Standard working voltage is 1000 V.D.C.

FIN-LOCK LEADS

Designed for holes from .050 to .058 Fin-Lock DISCAPS are automatically stopped in holes over .058 by the shoulder design of the leads. Stand up positioning is assured and lead crimping is eliminated. Available on all DISCAPS of standard voltages, ratings and spacings.

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CERAMIC
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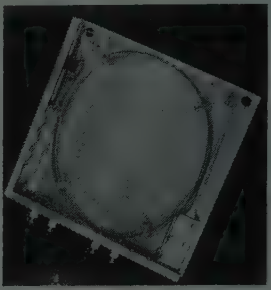
IRE BOOTH 3033

Whom and What to See at the Radio Engineering Show

(Continued from page 260A)

General Electric Co.
Heavy Military Electronics Dept.
Syracuse, N.Y.
Booth 2924

▲R. J. Brown, ▲G. D. Prestwich, ▲T. F. MacCoun, ▲N. R. Bibko, ▲J. J. Schoebel, ▲G. T. Wolfe, D. T. Hambleton



Wire Sonic Delay Lines

Design and manufacture of defense electronics equipment ranging from smallest components to the world's largest radar systems. With long delays per unit volume, adjustable or fixed delay, shock & vibration resistance, the Wire Sonic Delay Line is one of a wide range of G-E specialty electronic devices for defense—an adjunct to HMED's development of major military equipments for land-based and sea-borne detection, guidance, and control functions.

General Electric Company, Industrial Heating Dept., Booth 2932
Shelbyville, Ind.

Wayne Warden, Richard A. Gehr

Complete line of industrial soldering irons including wattages from 12 to 1200. Also, *new resistance soldering tool that completely eliminates arcing and provides high-speed-void-free connections which are critical considerations in the aircraft and missile industry.

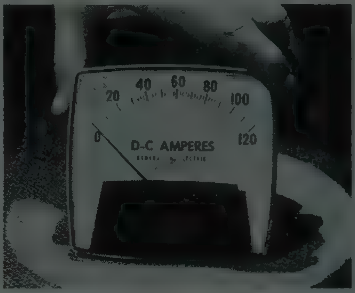
▲ Indicates IRE member.

* Indicates new product.

A complete listing of all registrants at the IRE National Convention and Radio Engineering Show, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

General Electric Co.
Instrument Dept.
West Lynn, Mass.
Booth 2928

J. E. McQuillan, E. R. Harrison, W. E. Cornish, W. J. Kearney, S. R. Sulis, M. W. Vittum, R. B. White, J. D. Henderson



*New 4½ inch Panel Meter

"Big Look" panel meters (indicating instruments)—2½- and 3½-inch, a-c, d-c, all ratings, sealed and shielded. *New 4½-inch model to be introduced. Also, a complete line of time meters.

General Electric Co., Laminated Products Dept., Booth 2914
Coshocton, Ohio

B. F. Brehl, W. H. Lewellen, R. T. Walsh, S. M. Bazler, R. R. Regan, R. Q. Dixon

G-E Textolite laminated plastics for printed circuit uses. Featuring TX-11559 epoxy-glass and TX-11574 epoxy-paper. Both are self-extinguishing.

General Electric Co., Large Lamp Dept., Booth 2916
Nela Park
Cleveland, 12, Ohio

A. MacKenzie, R. W. Hilbish, Jr., E. D. Smith, E. H. Tucker, R. J. Keyes, N. G. Grafton, K. C. Field, C. E. Bock, R. J. Somer, W. R. Becker, O. P. Gray, J. W. Tuttle, D. C. Miller, Warren R. Walker, L. C. Newsom, D. T. Swartfager, E. C. O'Hara, G. M. Parr, J. F. Saul.

Tungsten and Molybdenum metal products, electronic phosphors, lead wires and lamp bases along with pilot and indicator lamps.

General Electric Company, Magnetic Materials Section, Booth 2920
Erdmore, Mich.

M. E. Hartl, R. J. Studders, A. Marquis, R. J. Parker, R. P. Smith B. H. Fellows, G. D. Barcus, Jr., J. C. Betts, J. E. Foy, G. F. Mussen, J. P. Young, M. L. Chater, G. J. Anderson, G. R. Laughlin, H. Schwartz

Complete line of Alnico Permanent Magnets and typical applications. Thyrite® Varistors for voltage surge suppression. Thermistors for temperature compensation, measurement, and control. *New Positive Temperature Coefficient Thermistors.

(Continued cn page 265A)

NEW

- Airborne Digital Tape Recorder/Reproducer
- High Speed Digital Tape Bin Transport
- Analog & Digital Tape Heads
- Magnetic Memory Drums
- Memory Drum Heads

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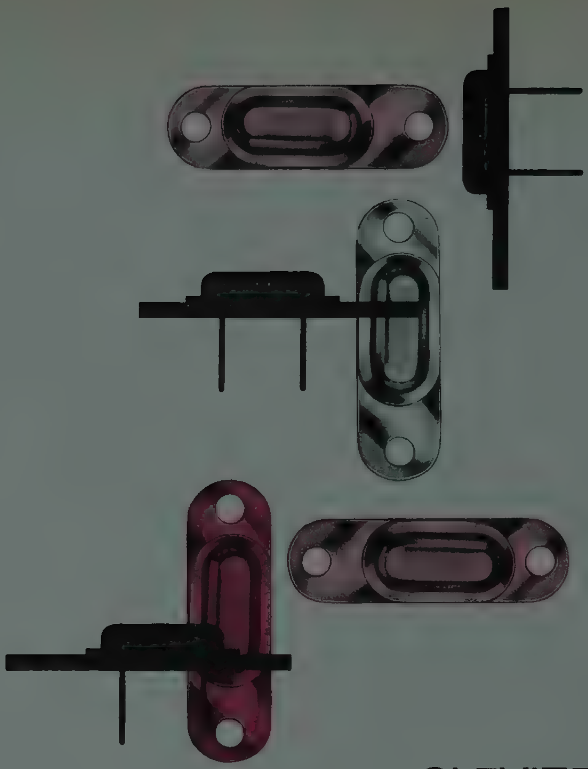
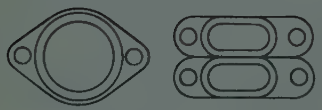


CLEVITE'S NEW
SPACESAVER
TRANSISTOR



½ actual size

THREE AMPERE SWITCHING TYPES

TEST	UNITS	CTP 1728	CTP 1735	CTP 1729	CTP 1730	CTP 1731	CTP 1736	CTP 1732	CTP 1733
Min BVcbo @ 2 ma	volts	40	60	80	100	40	60	80	100
Min BVceo @ 500 ma	volts	25	40	55	65	25	40	55	65
Min BVces @ 300 ma	volts	35	50	65	75	35	50	65	75
Max Icbo @ 85°C @ Max Vcb	ma	7	7	7	7	7	7	7	7
Typ. Icbo @ 2 V	μa	20	20	30	30	20	20	30	30
D. C. Current Gain @ 0.5A		30-75	30-75	30-75	30-75	60-150	60-150	60-150	60-150
Max Veb @ 3.0 A	volts	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max Vce(sat) @ 3.0A, 300 ma	volts	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Min fae @ 1.0 A	kc	15	15	8	8	10	10	6	6
Max Thermal Resistance	°c/w	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Compared with present power transistors of similar ratings, the new Clevite *Spacesaver* gives you important new advantages.

Better Switching — Its low base resistance gives lower input impedance for the same power gain and lower saturation resistance, resulting in lower "switched on" voltage drop. Its lower cut off current means better temperature stability in direct coupled circuits (such as regulated power supplies) and a higher "switched off" impedance.

Better Amplifying — Improved frequency response leads to higher audio fidelity, faster switching and improved performance in regulated power supply applications.

Better Mounting — The ***Spacesaver's*** simple rectangular configuration and low silhouette make it adaptable to a wide variety of mounting requirements where space is at a premium. In aircraft and missile applications, its low mass (half present type) improves shock and vibration resistance of lightweight assemblies.

A DIVISION OF
CLEVITE
CORPORATION

Phone for data and prices.

CLEVITE TRANSISTOR

254 Crescent Street Waltham 54, Mass. Tel: TWinbrook 4-9330

Whom and What to See at the Radio Engineering Show

(Continued from page 262A)

General Electric Co., Missile and Space Vehicle Dept., Booth 2920
3198 Chestnut St.
Philadelphia 4, Pa.
William Hoese
Military Electronics

General Electric Co.
Power Tube Dept.
Schenectady 5, N.Y.
Booths 2912-2914

▲ E. C. Numrych, ▲ G. W. Iler, E. A. DeMetre, E. T. Chace, ▲ W. F. McKeehan, R. H. Mack, ▲ C. G. Lob, R. R. Rottier, D. Hodges, E. C. White, A. C. Rowe, A. Michaelson, ▲ C. Karabats, K. E. Wilson, C. Vignola, H. L. Clark, ▲ Dr. M. Weinstein, ▲ H. Hannam, W. G. Granat, W. J. Pohl, ▲ Dr. P. Wargo

Power
TUBES

*New Ruggedized G-E Image Orthicon

Live demonstration of *new ruggedized G-E Image Orthicon operating under extremely low light levels. . . . *New L-band Voltage-Tunable Magnetron, S-band types plus *new ruggedized VTM design. . . . High-power, metal-ceramic hydrogen thyratrons. . . . Low-noise traveling-wave tubes.

General Electric Co.
Receiving Tube Dept.
Owensboro, Ky.
Booths 2906-2908

W. H. Clarke, ▲ L. T. Bowles, ▲ A. F. Dickerson, R. D. Kennedy, W. F. Greenwood, I. D. Daniels, ▲ E. H. Fritschel, ▲ J. R. Sommerville, ▲ A. P. Haase, ▲ R. E. Moe, C. A. Richardson, G. E. Burns, H. B. Nelson, J. E. Nelson, J. W. Gross, C. D. Cillie, R. A. Kittell, K. K. Krehbiel, Gordon Borgora, E. J. LaCroix, Jr., T. B. Jacocks, A. F. Bohner, R. H. Leach, C. L. Barnette, ▲ E. L. Davis, ▲ Lloyd Mumford, ▲ Frank Snyder, ▲ Bruce Angwin, Robert Hughes, George Crossland, Meredith Hamilton, Ken Weitzel

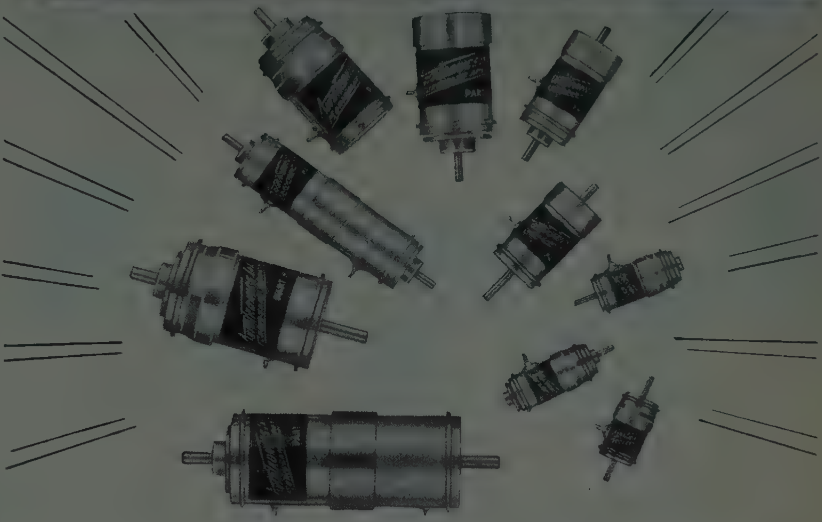
TIMM'S—Thermionic Integrated Micromodules

TIMM'S, ultra-tolerant micromodules; broad lines of ceramic tubes; Hi-Fi tubes, as well as 5-star military and industrial tubes, and service-designed tubes for TV and radio. Also shown—new developments in tube design.

(Continued on page 266A)

▲ Indicates IRE member.
* Indicates new product.

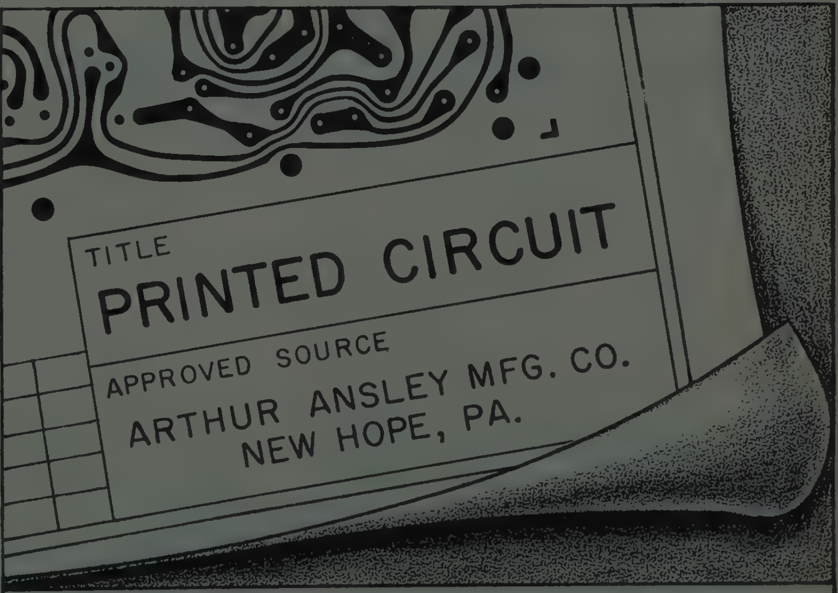
AUTOTRONICS VERSATILITY in sub-miniature, electro-magnetic clutch and brake units



120 standard model configuration selection. • weight range .8 oz. to 15.0 oz. • size range .500" dia. to 1.250" dia. servo mounting pilot. • torque value range 2 oz. in. to 60 oz. in.

Catalog with complete information on each clutch and brake is available without charge from

AUTOTRONICS INC
TEmple 7-3565
Rt. 1, Box 812
FLORISSANT, MO.
GREATER ST. LOUIS



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RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

Whom and What to See at the Radio Engineering Show

(*Continued from page 265A*)

General Electric Co.
Semiconductor Products Dept.
Electronics Park
Syracuse, N.Y.
Booth 2904

▲ H. Potter, H. Sweeney, ▲ W. Hall, ▲ N. Sampson, H. Lowry, B. Alexander, H. Taylor, W. Overstreet, H. Hodsdon, P. Hahn, A. Barko, J. Walton, W. Lupton, A. Woolaver, P. Burks, R. Bond, ▲ G. Curtiss, E. Hookway, C. Huyette, W. Halley, R. Olsen, A. Larmann, W. Robusto, G. Galliher, D. Morse, T. Burns, T. Loucas, L. Bassett, J. Teahan, R. Rogers, L. Mooney, ▲ H. W. Gebhardt, C. Goodman, D. Hickie

General Electric Tunnel Diode

The industry's quality semiconductors: *Tunnel diodes, *Silicon Unijunction Transistors, *Ceramic-disk Transistors, *Full line of Silicon and Germanium Transistors and Rectifiers, *Subminiatures, *Controlled Rectifiers, low, medium, high currents, *Selenium and Copper Oxide Rectifiers, *Silicon medium, low current Rectifiers.

General Electric Company, Silicone Products Department, Booth 2932
Waterford, N.Y.

J. W. Hawkins, J. S. Hurley, R. Treat, A. E. Horning, P. A. Goodwin, W. J. Dugan, R. A. Winter, G. A. Darsie

RTV (room temperature vulcanizing) liquid silicone rubber (including low viscosity RTV-11*) for potting, encapsulating, impregnating & mold making. Low-temperature-curing silicone impregnating varnish*. Silicone dielectric fluids & greases (including extreme low-temp. fluid*). High temperature silicone rubber wire insulation.

General Electric Company, Specialty Control Dept., Booth 2928
Waynesboro, Va.

D. F. Cross, H. E. Johnson, B. N. Berglund, R. D. Hawkins, C. R. Fullmer, R. A. Holcomb, G. E. Morris, G. M. Hausler

Sealed Relays—miniaturized high performance, high reliability; Complete mirco-miniature line features new four-pole unit, exclusive welded construction; and Unimite, world's smallest 1 amp relay offering high speed operation, isolated contact chamber. Line meets applicable MIL Specs.

General Electric Company, Voltage Regulator Section, Booth 2924
Pittsfield, Mass.

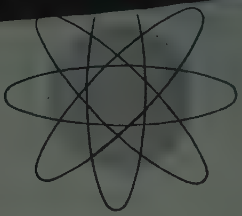
R. L. Maxon, C. A. Neumann, A. Terzano, T. R. Shortelle, H. R. Lumma

Rack mounted Inductrol® and *Sta-Vo-Trol voltage regulators for critical military and commercial applications. Sta-Vo-Trol static voltage regulator is a maintenance free design that eliminates tubes, brushes, and moving parts—utilizes unique rate-feedback and industry-proven zener diode sensing.

(*Continued on page 268A*)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 21-24, 1960

PCA PULSE TRANSFORMERS



PCA ELECTRONICS IS AMERICA'S PRIME
SUPPLIER OF PULSE TRANSFORMERS
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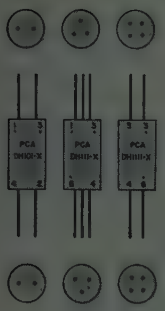
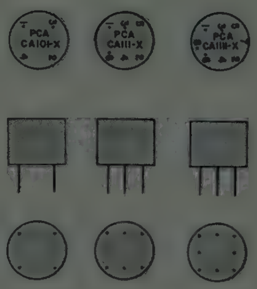
STANDARD PULSE TRANSFORMERS



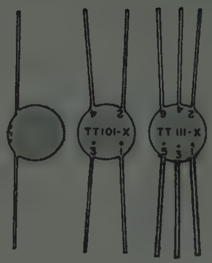
DH STYLE

Grain oriented silicon steel core. Internal assembly vacuum impregnated. Hermetically sealed. Electro-tin fused plating finish. Applicable specs: MIL-T-27, MIL-T-21038—Case B.



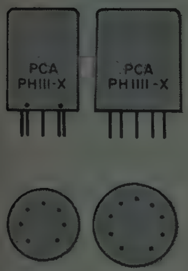
CA STYLE

Leads arranged in grid pattern. Grain oriented silicon steel. Available with ferrite cores. Internal assembly vacuum impregnated. Epoxy encapsulated. Applicable specs: MIL-T-27A, MIL-T-21038—Case A.



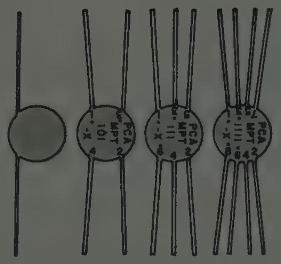
TT STYLE

Designed for low-level application in transistor circuitry. Grain oriented silicon steel. Internal assembly vacuum impregnated. Encapsulated in epoxy resin. Applicable specs: MIL-T-27, MIL-T-21038—Case E.



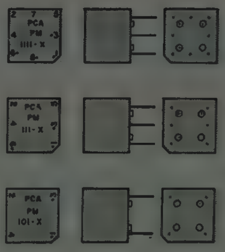
PH STYLE

Units plug in to 7- and 9-pin tube sockets. Grain oriented silicon steel. Internal assembly vacuum impregnated. Hermetically sealed. Electro-tin fused plating finish. Applicable specs: MIL-T-27, MIL-T-21038—Case C.



MPT STYLE

Grain oriented silicon steel. Internal assembly vacuum impregnated. Encapsulated with epoxy resin. Applicable specs: MIL-T-27A, MIL-T-21038—Case E.



PM STYLE

Leads arranged in grid pattern. Grain oriented silicon steel. Internal assembly vacuum impregnated. Case materials in glass alkyd. Applicable specs: MIL-T-27, MIL-T-21038 — Case H.

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DESIGNED TO ORDER

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Booths 2342-2344

Whom and What to See at the Radio Engineering Show

(Continued from page 266A)

General Findings and Supply Co.

Industrial Div.
Attleboro, Mass.
Booth 4052

Gerald F. Tucci, Fred Dole, Sam Greenbaum, Arthur O. Marcello, Jr., Peter Microulis, B. Hocker

Miniature precious metal contacts and assemblies. Rivets, Brushes, Slip Rings, Special Shapes. All standard contact Gold, Silver, Platinum and Palladium. Base metal precision fabrications.

General Instrument Corp., Defense & Engineering Products Group, Booths 1218-1224
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Brooklyn 11, N.Y.

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System design & production in radar, identification, communication, microwave telephone & telegraph systems, navigation, guidance, beaconry, telemetry, air traffic control, sonar & ultrasonics, airport instrumentation, meteorology, thermoelectric devices, and transducers.

General Instrument Corp., Radio Receptor Co., Inc., Subsid., & Micamold Electronics Mfg. Corp., Div., Booths 1218-1224

See: Radio Receptor Co., Inc. & Micamold Electronics Mfg. Corp.

▲ Indicates IRE member.
* Indicates new product.

Lecture Halls in the Coliseum are located on the Fourth Floor. See complete program of speakers and papers in the editorial section of this issue.

General Instrument Corp.

Semiconductor Div.
65 Gouverneur St.
Newark 4, N.J.
Booth 1218-1224

D. Adler, M. Barmat, H. Chapman, G. Fox, M. Friedman, A. Gartner, V. Griski, S. Gross, S. Gurion, H. Hagler, A. Kosowkoski, M. Lissner, J. Loebenstein, A. Nash, H. Nash, P. Pritchard, C. Schuler, A. Sikorsky, S. Soloman, J. Tucker, S. Winuk

Miniature glass silicon & germanium diodes, all purpose silicon diode IN 658, complete line JAN silicon power rectifiers. "Tri-amp," "Petti--sel" high current density selenium rectifiers—100,000 hrs. of life expectancy, "ABC series" miniature rectifiers. "Missilmite," smallest molded mica capacitor for military.

General Magnetic Corp., Booth 1904
4937 Fullerton Ave.
Chicago 39, Ill.

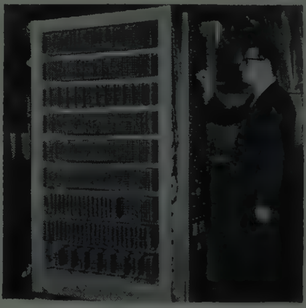
W. E. Gilman, ▲ R. T. Thompson, ▲ P. Gebhardt, R. Campbell, F. Da Roza

Magnets, magnetic metals and materials.

General Mills, Inc.

Mechanical Division
1620 Central Ave. N.E.
Minneapolis 13, Minn.
Booths 3937-3939

▲ Richard Quinn, ▲ Francis Alterman, ▲ Stuart Ulfers, Leonard Kriedemacher, Ted Conant, Lloyd Pearson



The General Mills 2003 Computer*

"General Mills 2003" is a medium size, general purpose digital computer offering high performance and reliability at moderate cost. Fully transistorized, this usually versatile computer is readily adaptable to applications where external equipment must be integrated into a system.

General Motors Corp., Booth 1226
See: Delco Radio Division.

(Continued on page 273A)

Synchronize UNIVERSAL Toroidal Coil Winding Service with your production line

Universal Toroidal Coil Winding Service comprises custom design and/or production of inductors, transformers, magnetic amplifiers, oscillator coils, filters, potentiometer windings, etc. *We specialize also in high frequency toroidal inductors and transformers, featuring extremely low distributed capacity and high coupling coefficient.* Universal components are produced in open, encased, encapsulated, MIL-T-27A, or commercial construction.

See our exhibit, Booth 4415-4417
IRE NATIONAL CONVENTION

UNIVERSAL TOROID COIL WINDING, INC.
171 Coit St., Irvington 11, N.J.
ESsex 4-9804

NEW FROM JFD LUMPED CONSTANT DELAY LINES

Meet the newest addition to the growing family of JFD precision electronic components.

Designed with compactness, ruggedness and reliability in mind, new JFD lumped constant Delay Lines upgrade your prototype or production project.

Compare the advantages of the standard JFD lumped constant delay lines:

- High delay-to-rise time ratio with minimum signal attenuation.
- Tolerance of ±5% max. on delay and characteristic impedance.
- Temperature range of −55° C to +125° C.
- Delay time thermal stability of 50 parts per million per degree centigrade.
- Up to 25 Mc bandwidth.
- Virtually linear phase shift.
- Hermetically sealed metal cases for maximum resistance to shock, vibration and humidity.
- Meet all applicable MIL specs.

Typical Standard Delay Line Characteristics

Delay Time 5 μ sec.		10 μ sec.		25 μ sec.	
Rise Time	Size	Rise Time	Size	Rise Time	Size
1.0	$1\frac{1}{8}\times1\frac{1}{8}\times2\frac{1}{4}$	2.0	$1\frac{1}{2}\times1\frac{1}{2}\times3$	5.0	$1\frac{7}{16}\times1\frac{7}{16}\times2\frac{7}{8}$
.5	$1\frac{5}{16}\times1\frac{5}{16}\times2\frac{5}{8}$	1.0	$1\frac{5}{8}\times1\frac{5}{8}\times3\frac{1}{4}$	2.5	$1\frac{3}{4}\times1\frac{3}{4}\times3\frac{1}{2}$
.3	$1\frac{3}{8}\times1\frac{3}{8}\times2\frac{3}{4}$	.6	$1\frac{3}{4}\times1\frac{3}{4}\times3\frac{1}{2}$	1.5	$2\frac{7}{16}\times2\frac{7}{16}\times4\frac{7}{8}$
.15	$2\frac{1}{4}\times2\frac{1}{4}\times4\frac{1}{2}$	.3	$2\frac{1}{4}\times2\frac{1}{4}\times4\frac{1}{2}$	.75	$2\frac{3}{4}\times2\frac{3}{4}\times5\frac{1}{2}$

Range of characteristic impedance: 50 ohms to 2000 ohms ±5%.
Attenuation: Less than 1db per μ sec. up to 3 μ sec. delay; 6db max. up to 50 μ sec. delay.
Temperature stability: 50 parts per million per degree C from −55° to +125° C.

Whether your application calls for standard or custom-built lumped constant or distributed constant delay lines, our engineering staff will be glad to review your needs and submit recommendations. Closer tolerance delays and impedances are available, in forms, sizes and terminal designs to match your needs. Write for Bulletin No. 213A.

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Pioneers in electronics since 1929

ELECTRONICS CORPORATION

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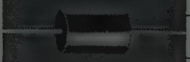
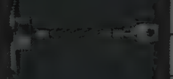
JFD International, 15 Moore Street, New York, New York
JFD Canada Ltd., 51 McCormack Street, Toronto, Ont., Canada

TARZIAN

designer's line

silicon rectifiers include 84 high efficiency types

amps. DC (100° C)		peak inverse voltage	max. RMS volts	max. amps. recurrent peak	max. amps. surge 4MS	Tarzian Type	Jedec No.
0.325		2800	1960	3.25	19.5	280SM	1N1113
0.35		2400	1680	3.5	21	240SM	1N1112
0.375		2000	1400	3.75	22.5	200SM	1N1111
0.4		1600	1120	4	24	160SM	1N1110
0.425		1200	840	4.25	25.5	120SM	1N1109
0.45		800	560	4.5	27	80SM	1N1108
0.5		100	70	5	30	10M	1N1081
		200	140	5	30	20M	1N1082
		300	210	5	30	30M	1N1083
		400	280	5	30	40M	1N1084
		400	280	5	30	M-500	1N1084
		500	350	5	30	50M	—
		600	420	5	30	60M	—
		200	140	7.5	75	F-2	1N2482
		400	280	7.5	75	F-4	1N2483
		600	420	7.5	75	F-6	1N2484
0.75		100	70	7.5	75	10H	—
		200	140	7.5	75	20H	1N2485
		300	210	7.5	75	30H	1N2486
		400	280	7.5	75	40H	1N2487
		500	350	7.5	75	50H	1N2488
		600	420	7.5	75	60H	1N2489

amps. DC (100° C)		peak inverse voltage	max. RMS volts	max. amps. recurrent peak	max. amps. surge 4MS	NEGATIVE Tarzian Type	NEGATIVE Jedec No.	POSITIVE Tarzian Type	POSITIVE Jedec No.
1.5		100	70	10	100	—	—	10J1	1N1617
		200	140	10	100	—	—	20J1	1N1618
		300	210	10	100	—	—	30J1	1N1619
		400	280	10	100	—	—	40J1	1N1620
2		100	70	30	100	—	—	10LA	1N1085
		200	140	30	100	—	—	20LA	1N1086
		300	210	30	100	—	—	30LA	1N1087
		400	280	30	100	—	—	40LA	1N1088
10		100	70	50	150	—	—	10J2	1N1621
		200	140	50	150	—	—	20J2	1N1622
		300	210	50	150	—	—	30J2	1N1623
		400	280	50	150	—	—	40J2	1N1624
20		50	35	120	200	5RAN	1N1157	5RAP	1N1171
		100	70	120	200	10RAN	1N1158	10RAP	1N1172
		200	140	120	200	20RAN	1N1159	20RAP	1N1173
		300	210	120	200	30RAN	1N1160	30RAP	1N1174
		400	280	120	200	40RAN	—	40RAP	—
35		50	35	210	350	5SAN	1N1161	5SAP	1N1175
		100	70	210	350	10SAN	1N1162	10SAP	1N1176
		200	140	210	350	20SAN	1N1163	20SAP	1N1177
		300	210	210	350	30SAN	1N1164	30SAP	1N1178
		400	280	210	350	40SAN	—	40SAP	—

Rated at from 0.325 to 250 amps, in complete variety of case designs and terminals

Proved performance, low cost, prompt shipment from stock

Sarkes Tarzian's "Designers' Line" silicon rectifiers offer the small size, high efficiency, mounting versatility, and wide range of ratings that can help solve many of your power conversion circuitry problems. Tarzian's realistic prices make these high quality components practical for almost all commercial and military applications.

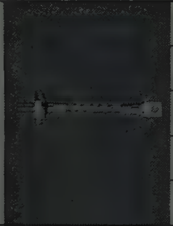
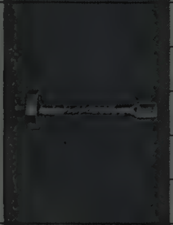
The 84 types of Tarzian "Designers' Line" rectifiers feature extremely low junction current density to provide maximum reliability and operating life.

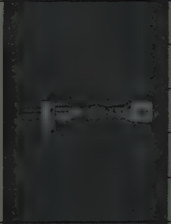
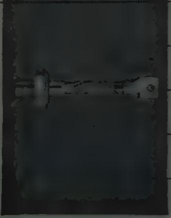
Their −55°C to +125°C temperature range makes Tarzian silicon rectifiers ideal for circuits where ambient temperatures are high and small size is desired. Ratings range from 0.325 to 250 amperes.

Tarzian types are available for immediate delivery in production quantities from factory or warehouse stocks. Complete power conversion engineering service on your rectifier requirements is available at no charge or obligation.

For further information contact your nearest Tarzian sales representative or write to Section 4394D, Semiconductor Division, Sarkes Tarzian, Inc., Bloomington, Indiana.

SARKES TARZIAN, INC.
SEMICONDUCTOR DIVISION
BLOOMINGTON, INDIANA
In Canada: 700 Weston Rd., Toronto 9, Ontario
Export: Ad Auriema, Inc., New York City

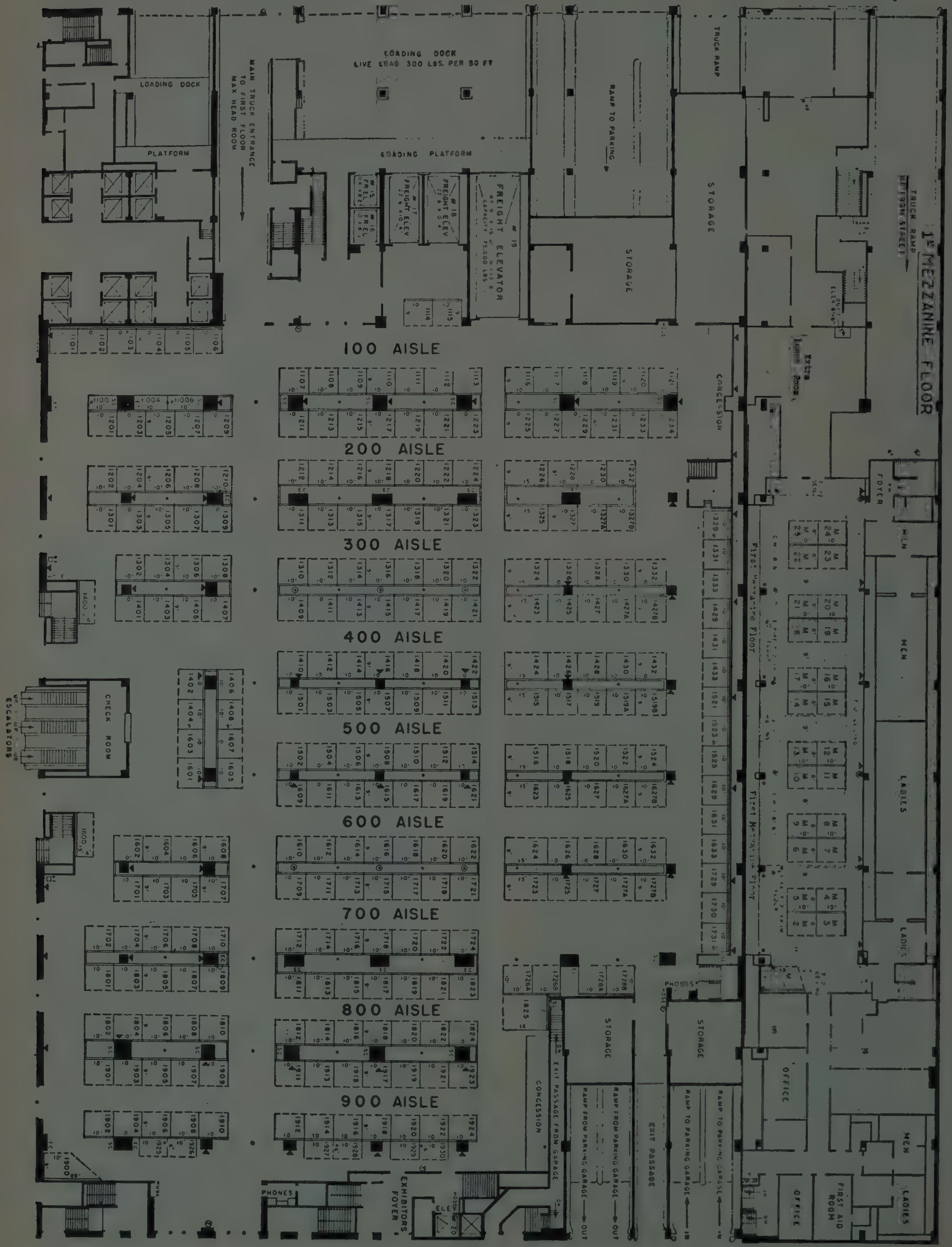
amps. DC (100° C)		peak inverse voltage	max. RMS volts	max. amps. recurrent peak	max. amps. surge 4MS	NEGATIVE Tarzian Type	NEGATIVE Jedec No.	POSITIVE Tarzian Type	POSITIVE Jedec No.
35		50	35	210	350	5S3N	–	5S3P	–
		100	70	210	350	10S3N	–	10S3P	–
		200	140	210	350	20S3N	–	20S3P	–
		300	210	210	350	30S3N	–	30S3P	–
		400	280	210	350	40S3N	–	40S3P	–
100		50	35	600	1000	5VAN	1N1165	5VAP	1N1179
		100	70	600	1000	10VAN	1N1166	10VAP	1N1180
		200	140	600	1000	20VAN	1N1167	20VAP	1N1181
		300	210	600	1000	30VAN	1N1168	30VAP	1N1182
		400	280	600	1000	40VAN	–	40VAP	–
		50	35	600	1000	5V3N	–	5V3P	–
		100	70	600	1000	10V3N	–	10V3P	–
		200	140	600	1000	20V3N	–	20V3P	–
		300	210	600	1000	30V3N	–	30V3P	–
		400	280	600	1000	40V3N	–	40V3P	–
150		50	35	900	1500	5WAN	1N1263	5WAP	1N1267
		100	70	900	1500	10WAN	1N1264	10WAP	1N1268
		200	140	900	1500	20WAN	1N1265	20WAP	1N1269
		300	210	900	1500	30WAN	1N1266	30WAP	1N1270
		400	280	900	1500	40WAN	–	40WAP	–

amps. DC (100° C)		peak inverse voltage	max. RMS volts	max. amps. recurrent peak	max. amps. surge 4MS	NEGATIVE Tarzian Type	NEGATIVE Jedec No.	POSITIVE Tarzian Type	POSITIVE Jedec No.
150		50	35	900	1500	5W3N	–	5W3P	–
		100	70	900	1500	10W3N	–	10W3P	–
		200	140	900	1500	20W3N	–	20W3P	–
		300	210	900	1500	30W3N	–	30W3P	–
		400	280	900	1500	40W3N	–	40W3P	–
200		50	35	1200	2000	5XAN	1N1263A	5XAP	1N1267A
		100	70	1200	2000	10XAN	1N1264A	10XAP	1N1268A
		200	140	1200	2000	20XAN	1N1265A	20XAP	1N1269A
		300	210	1200	2000	30XAN	1N1266A	30XAP	1N1270A
		400	280	1200	2000	40XAN	–	40XAP	–
		50	35	1200	2000	5X3N	–	5X3P	–
		100	70	1200	2000	10X3N	–	10X3P	–
		200	140	1200	2000	20X3N	–	20X3P	–
		300	210	1200	2000	30X3N	–	30X3P	–
		400	280	1200	2000	40X3N	–	40X3P	–
250		50	35	1500	2500	5Y3N	–	5Y3P	–
		100	70	1500	2500	10Y3N	–	10Y3P	–
		200	140	1500	2500	20Y3N	–	20Y3P	–
		300	210	1500	2500	30Y3N	–	30Y3P	–
		400	280	1500	2500	40Y3N	–	40Y3P	–

Floor Plan—First Floor

Components

First floor mezzanine is at right side of plan. Entrances to this area are next to booths 1329 and 1731.


LOADING DOCK
PLATFORM
MAIN TRUCK ENTRANCE TO FIRST FLOOR MAX HEAD ROOM
LOADING DOCK LIVE LOAD 300 LBS. PER SQ FT
LOADING PLATFORM
FREIGHT ELEV
#19 FREIGHT ELEVATOR
RAMP TO PARKING
STORAGE
TRUCK RAMP
TRUCK RAMP AT 13TH STREET
1st MEZZANINE FLOOR
100 AISLE
200 AISLE
300 AISLE
400 AISLE
500 AISLE
600 AISLE
700 AISLE
800 AISLE
900 AISLE
CONCESSION
Extra Lunch Room
FOYER
MEN
LADIES
First Mezzanine Floor
CHECK ROOM
ESCALATORS
PHONES
EXHIBITORS FOYER
EXIT PASSAGE FROM GARAGE
RAMP FROM PARKING GARAGE
OUT
IN
EXIT PASSAGE
RAMP TO PARKING GARAGE
OFFICE
FIRST AID ROOM

Whom and What to See at the Radio Engineering Show

(Continued from page 268A)

General Precision, Inc., Formerly General Precision Equipment Corp., Booths 1501-1511

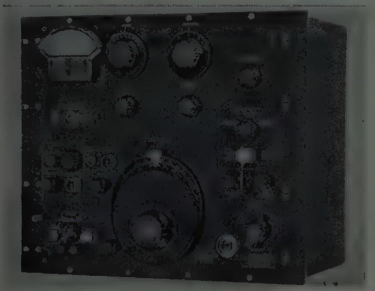
See: GPL Division, Kearfott Division, Librascope Division, Link Division.

General Precision Laboratory Inc., Booth 1505

See: GPL Division, General Precision, Inc.

General Radio Co.
22 Baker Ave.
West Concord, Mass.
Booths 3201-3208

▲ A. E. Thiessen, ▲ Myron T. Smith, ▲ W. R. Saylor, ▲ S. W. DeBlois, ▲ P. J. Macalka, ▲ R. K. Peterson, ▲ R. A. Boole, ▲ W. R. Thurston, ▲ R. B. Richmond, ▲ C. J. Lahanas, ▲ R. A. Jokinen, ▲ C. E. Worthen, ▲ M. A. Gilman, ▲ L. J. Chamberlain, ▲ E. F. Sutherland, ▲ K. Adams, ▲ C. W. Harrison, ▲ F. J. Finnegan, R. E. Wilson, ▲ I. G. Easton, ▲ R. W. Frank, ▲ E. Karplus, ▲ G. G. Ross, ▲ P. Bishop, ▲ D. W. Brown, ▲ J. E. Snook, ▲ J. C. Held, ▲ H. H. Dawes, R. H. Reinstra, ▲ D. B. Sinclair, ▲ A. P. G. Peterson, ▲ M. C. Holtje



*Type 1300-A Beat-Frequency Video Generator

Complete impedance standards and measurements laboratory, with impedance measuring equipment from dc to 5000 Mc; *pulse generators; *video-frequency signal generator for sine-wave, square-wave, and sweep testing; *random-noise generator; graphic level recorder; audio and acoustical instruments; automatic voltage regulator; display of design features.

General Resistance, Inc.
430 Southern Blvd.
New York 55, N.Y.
Booth 3026

▲ Charles Jasik, ▲ Lawrence Merson, ▲ Rubin Blumkin, Mike Lombardozzi, Sam Freed

Precision Wheatstone Bridge

Precision wheatstone bridge—0.0035 accuracy. Precision wire wound resistors, precision resistance networks, voltage dividers, resistance standards, summing networks (DC and 400 cps), cold junction compensators, special temperature coefficient resistors, analog-digital networks.

(Continued on page 275A)

▲ Indicates IRE member.
* Indicates new product.

Dr. Lucius Cuppington introduces . . .

VERNITEL, heart of HOOVER's new FM/FM telemetering system that prolongs the life of FM/FM systems now in use, improving their accuracy by a whole order of magnitude:

Count Vladimir Butts Binswinger shows . . .

HOOVER's new Mixer Amplifier, the palm-sized part of the Vernitel system that helps FM/FM telemetering systems live beyond their income, by prolonging their lives amazingly:

Personalities

at the

HOOVER

ELECTRONICS COMPANY

IRE Show Booth: No. 3844

Sir Joshua Wormwood Scrubbs offers . . .

HOOVER's new Millivolt Transistorized Oscillator that eliminates DC amplification from telemetering, allowing fewer and smaller packages and an end to one source of error:

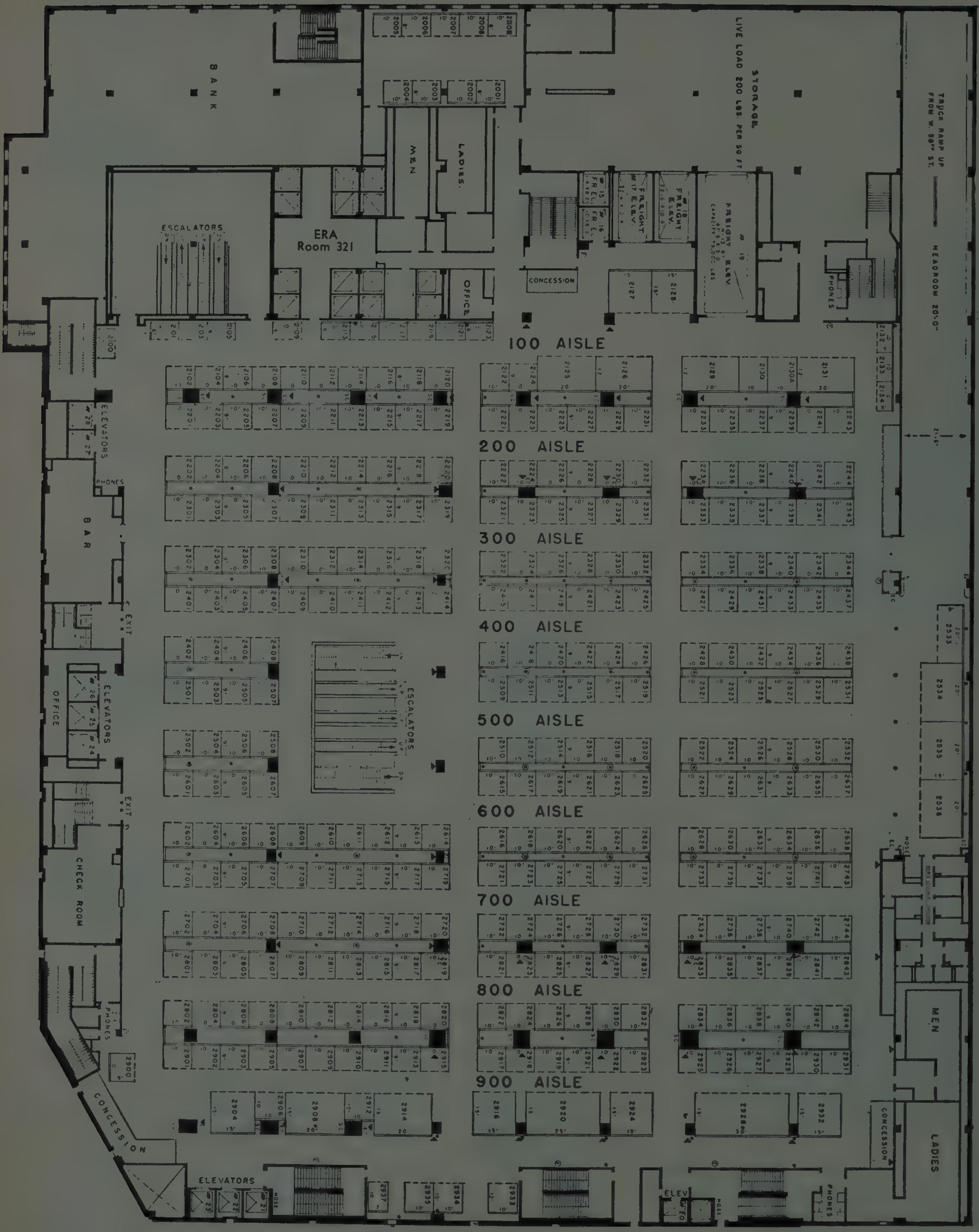
Dr. Herpes Zoster introduces . . .

HOOVER's new Transistorized Subcarrier Oscillator, for FM/FM telemetering circuits, offering a linearity within 0.3% of band-width and a frequency stability within 1.5%.

See them at the IRE Show, March 21-24 . . . or ask for the literature and specification sheets.

HOOVER
ELECTRONICS COMPANY
SUBSIDIARY OF THE HOOVER COMPANY
110 WEST TIMONIUM ROAD • TIMONIUM, MARYLAND
Field Liaison Engineers
Los Angeles, California

Floor Plan—Second Floor
Components


SECOND FLOOR
BANK
ESCALATORS
ERA Room 321
MEN
LADIES
OFFICE
CONCESSION
STORAGE
LIVE LOAD 200 LBS. PER SQ FT
FREIGHT ELEV.
TRUCK RAMP UP FROM W. 50th ST.
HEADROOM 20'-0"
PHONES
100 AISLE
200 AISLE
300 AISLE
400 AISLE
500 AISLE
600 AISLE
700 AISLE
800 AISLE
900 AISLE
ELEVATORS
BAR
EXIT
OFFICE
CHECK ROOM
ESCALATORS
CONCESSION
ELEVATORS
ELEV
MEN
CONCESSION
LADIES

Be sure to visit the South Room which is on the same level, 70 feet off the main floor in the center of the south wall.

Whom and What to See at the Radio Engineering Show

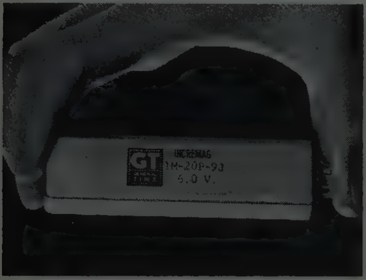
(Continued from page 273A)

General Telephone and Electronics Corp., Booths 1906-1908, 2322-2332, 2415-2425

See: Automatic Electric Sales Corp. & Sylvania Electric Products Inc.

General Time Corp.
109 Lafayette St.
New York 17, N.Y.
Booth 1726A

R. W. Behringer, ▲ M. Lace, ▲ W. P. Byrnes, C. B. Higgins, ▲ Dr. W. C. Anderson



INCREMAG—9 Decade Counter

INCREMAG—Magnetic counter—divider, useful in frequency division, timing, programming, control, logic, memory use, computers, etc. Unit above accepts random frequencies 0-20,000 pps and is nine decade counter. All outputs available. Industrial or military specifications. Furnished as components or systems.

General Transistor Corp., Booths 1212-1214
91-27 138th Pl.
Jamaica 35, N.Y.

▲ James Evans, ▲ Howard Peaceman, ▲ Frank Sopchick, ▲ Robert Johnson, ▲ Charles Askanas, ▲ Ted Liebfried, ▲ Edwin Berlin, Joseph Wright, Stephen Tolles, ▲ James Egan

Germanium and Silicon Transistors, Semiconductor Diodes, Bobbinless Precision Wire Wound Resistors. Magnetic Recording Heads (Magne-Head Div.)

Genisco, Incorporated, Booth 3244
2233 Federal Ave.
Los Angeles 64, Calif.

Jack Kimble, William Tikanen, Alex Weiss, Milton Slawinski

Special motors, electronic networks, a rate-of-turn table, miniature indicating lights, and accelerometers. Operating displays include Genisco servo-operated rate-of-turn table with Micro-Rate Accessory which permits rates as low as 0.0001° per second, a special 40-pole, wound-rotor synchronous motor, and a working accelerometer display.

Georator Corp., Booths 1230-1232

See: Travco Associates.

Geotechnical Corporation, Booth 3240
3401 Shiloh Rd.
Garland, Texas

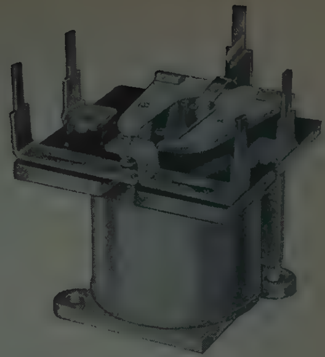
Frank E. Gaillard, Jack H. Hamilton, James R. Womack, Robert F. McMurray

Transistorized Timing System, modular: frequency standard, recording time-mark programmer, precise 60-cps power source, WWV comparator—stability 1 part in 10^7 per week.
FM Telemetering Subcarrier Discriminator, Ground-Station Voltage Controlled Oscillator. Infrasonic Amplifier—.025 microvolt noise level. Automatic Chart Reader (Curve-Follower).

(Continued on page 277A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

For Printed Circuitry



Price PRESENTS STYLE 1005

MIDGET DC RELAY

Cut your material and direct labor costs with this small, inexpensive, mass-produced relay for use in printed circuitry where the relay is self-supporting. Designed for simple plug-in installation.

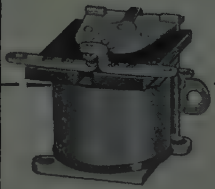
The Style 1005 Relay is a single-pole, double-throw relay, light in weight yet capable of withstanding severe operating conditions and rough handling.

TYPICAL APPLICATIONS

Remote TV Tuning, Control circuits for recording instruments, Radiosonde, Auto headlight dimming, etc.

GENERAL CHARACTERISTICS

STANDARD OPERATING VOLTAGES ....3 to 32 VDC
MAXIMUM COIL RESISTANCE ....13,000 ohms
SENSITIVITY ....0.05 watt at standard contact rating; 0.3 watt at maximum contact rating
CONTACT COMBINATION ....SPDT
CONTACT RATING ......Standard 1 amp.; optional ratings, with special construction, to 3 amps. Ratings apply to resistive loads to 26.5 VDC or 115 VAC
MECHANICAL LIFE EXPECTANCY .....10,000,000 operations minimum
DIELECTRIC STRENGTH .....500 VRMS minimum



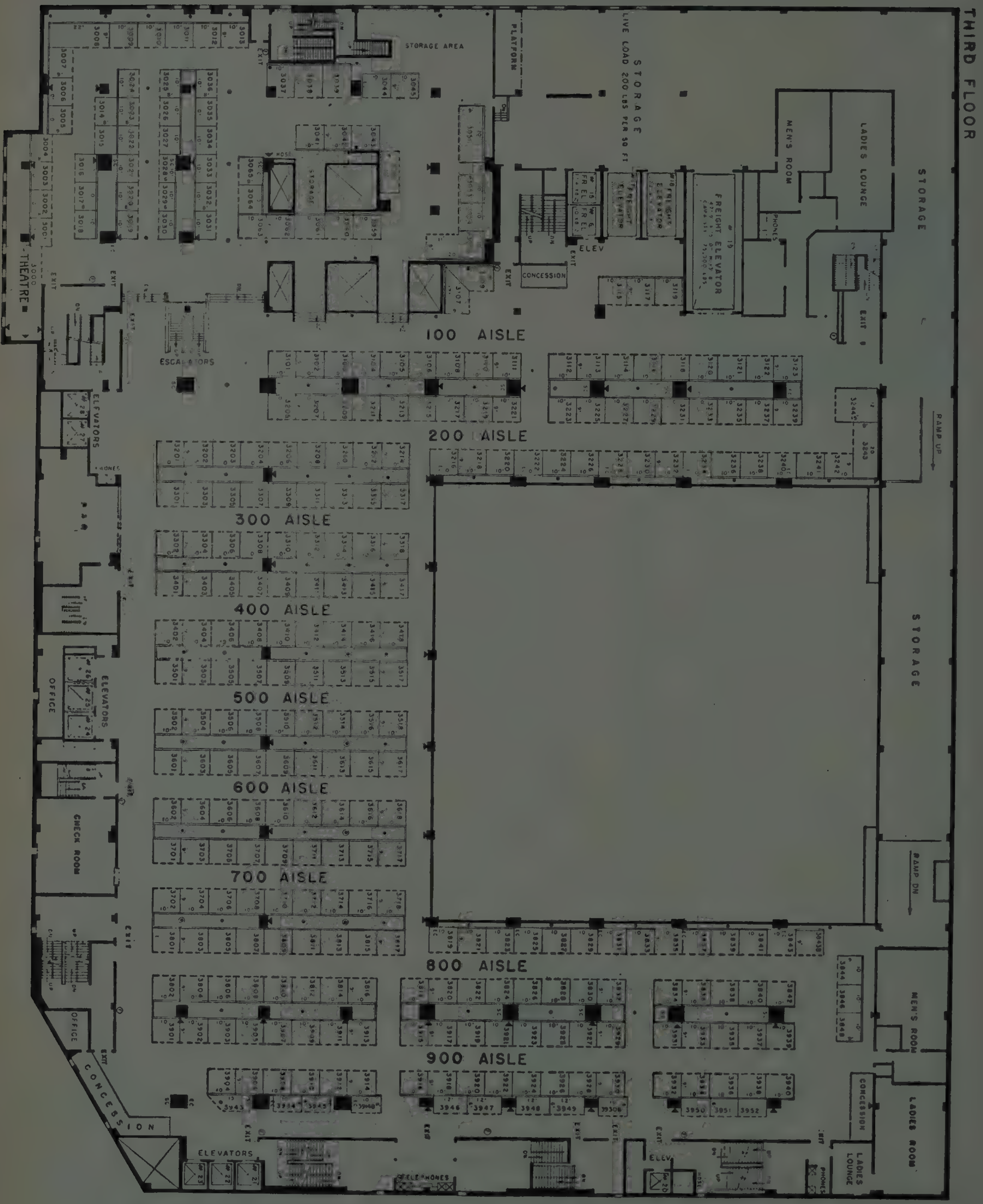
Also available with solder lugs in open or hermetically sealed styles.

STYLE 1001

For Details, call or write
PRICE ELECTRIC CORPORATION
300 E. Church Street
FREDERICK, MARYLAND
MOnument 3-5141
TWX: Frederick, Md. 565-U

Floor Plan—Third Floor Instruments & Complete Equipment

Communications Equipment & Systems, Computers, and Instruments for test and measurement, microwave equipment.


THIRD FLOOR
STORAGE AREA
PLATFORM
STORAGE
LIVE LOAD 200 LBS PER SQ FT
MEN'S ROOM
LADIES LOUNGE
STORAGE
FREIGHT ELEVATOR
PHONES
CONCESSION
ELEV
EXIT
3000 THEATRE
ESCALATORS
ELEVATORS
100 AISLE
200 AISLE
300 AISLE
400 AISLE
500 AISLE
600 AISLE
700 AISLE
800 AISLE
900 AISLE
RAMP UP
RAMP DN
OFFICE
CHECK ROOM
OFFICE
CONCESSION
ELEVATORS
TELEPHONES
MEN'S ROOM
CONCESSION
LADIES ROOM
LADIES LOUNGE
PHONES

Escalators at the sound end of the main lobby take you direct to the third floor. Be sure to see the booths in the "3000 Court" at the south-east corner of the floor.

Whom and What to See at the Radio Engineering Show

(Continued from page 275A)

Gertsch Products, Inc.
3211 S. La Cienega Blvd.
Los Angeles 16, Calif.
Booths 3701-3703

▲ E. P. Gertsch, ▲ E. W. Watts, R. M. Bloniarz, H. F. Richardson, H. P. Faris

Model CRB

AC Voltage Standard; Automatic Complex Ratio Bridge; .0001% Accurate VHF Frequency Meter; Microwave Frequency Multiplier; FM Deviation Meter; Frequency Converter; AC & DC Ratio Standards; Coaxial Switch, Per Cent Deviation, Programmable and Shaft Driven Ratio Transformers, Special Transformers.

Giannini Controls Corp., Booths 1428-1430
918 E. Green St.
Pasadena 1, Calif.

Carl E. Calohan

Air Data Instruments dealing with pressure, altitude, true air speed, pressure ratio, Mach Number, temperature probes and vanes, and featuring the Mach Switch; Inertial Instruments—accelerometers, gyros; Precision Servo Instruments—potentiometers, pressure switches, stepping motors; Systems-featuring TAS, Thrustmeter, and Precision Voltage Monitor Systems.

Glasseal Products Co., Inc., Booth 1517
725 Commerce Rd.
Linden, N.J.

Alexander Anderson, K. G. Crocker, Gus Eichelhardt, Jack Goss, Frank Emmet, Russ Diethert, R. Sidnell, Jack Logan, Fred Peterson, David Humes

*Featuring the new Glass-to-Copper Transistor Terminations. Complete line of Standard and Custom-Designed Vacuum-Tight High Compression and Kovar Glass-to-Metal Seals. Transistor terminations, Diodes, Connectors, Leaders, Endseals, Feed-thrus, Stand-offs, Plus "Sealing only" service.

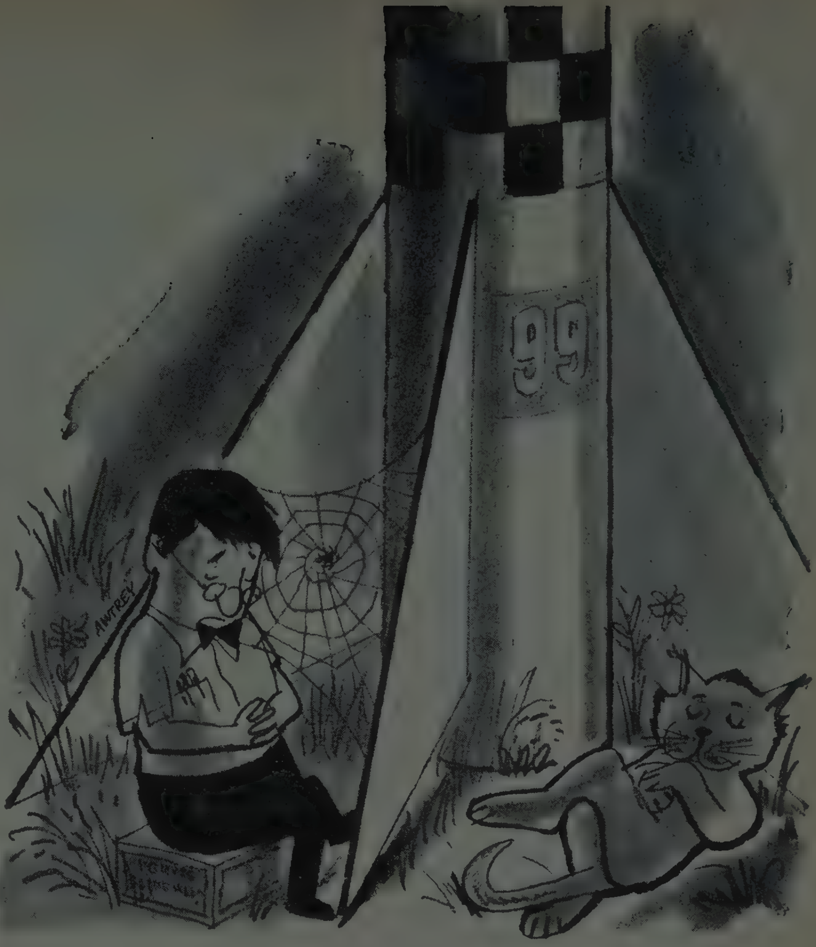
Glass-Tite Industries, Inc.
725 Branch Ave.
Providence 4, R.I.
Booth 1109

John A. Dodenhoff, Ralph R. Papitto, Frank W. Brakenwagen, Jr., Philip Schumacher, Christian D. Berger, Maurice Grosso, Bernard J. Scorza, Leroy W. Beier, Milton Paisner, Gramer Yarbrough, Gerard V. Dube

Complete line of glass-to-metal hermetic seals for the relay industries, semiconductor manufacturers, terminal-feed-thrus, end seals for the capacitor and transformer manufacturers and crystal bases. "D" series line of hermetically-sealed and plastic connectors.

(Continued on page 279A)

Be sure to
see all four floors!



still waiting for your pots?

Are your pot delivery schedules figured in weeks instead of days? If you're a member of the Pot Waiter's Club, read on:

At ACE, we fully inventory *all* parts for our complete standard line! And when a pot *has* to be made from scratch — we cut time there, too. All raw materials are warehoused, and a complete machine shop, including Swiss screw machines, is maintained. Our special prototyping department lops the time off special requirements.

Prepared engineering releases and part prints for standard pots await your incoming order. That's why, within hours after receipt, your order for standards is into manufacturing! So specify from Ace's comprehensive line of standards, in full resistance ranges, sizes, configurations and functions. Your "special spec" is probably among our standard line — and that means time and money saved for you!

This 1-1/16" ACEPOT®, typifying the entire standard line, is available on prompt delivery!

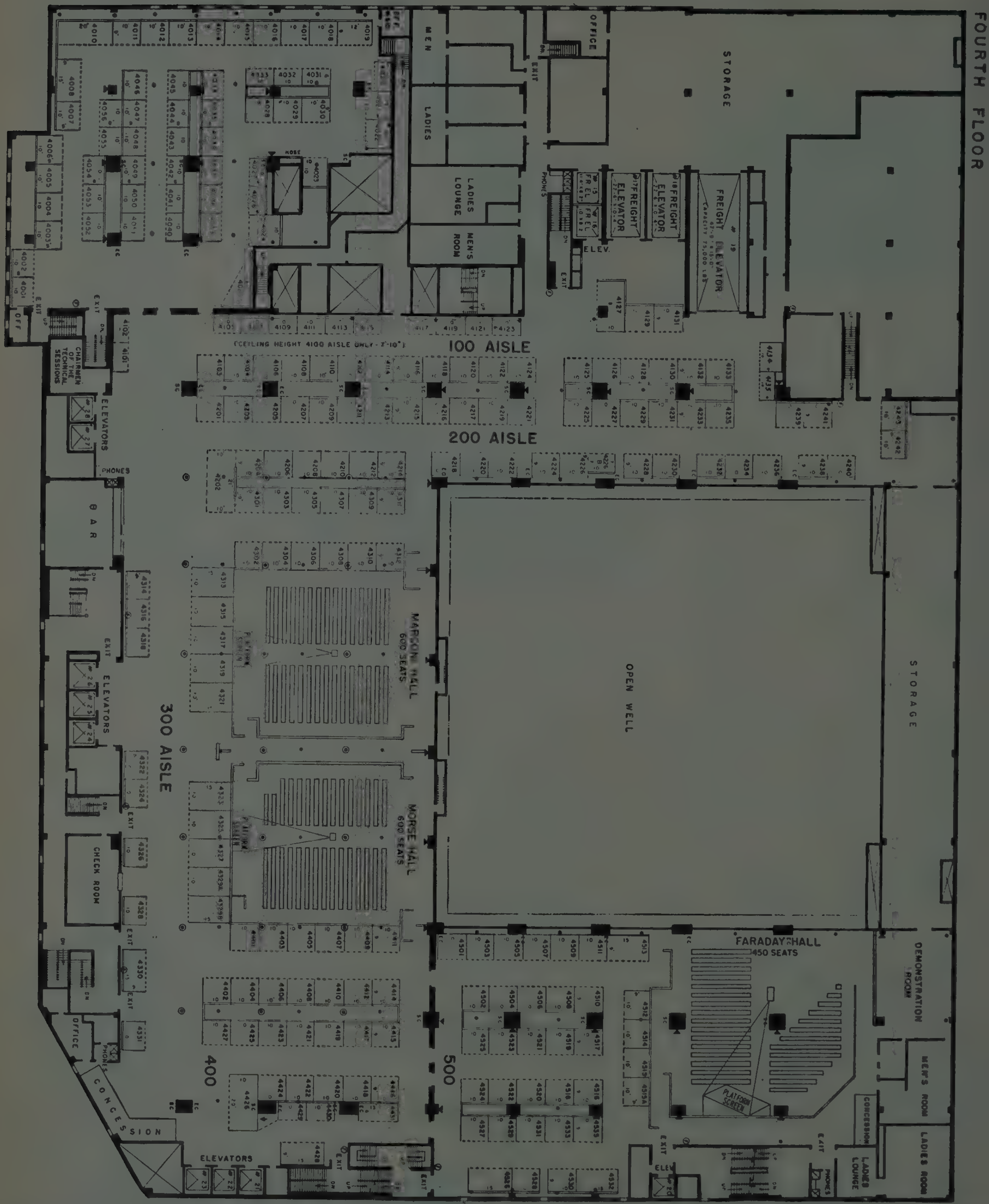
See us at IRE   Booth 1811-1813

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOmerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim* Aceset® Aceohm® *Reg. Appl. for

Floor Plan—Fourth Floor
Production

Machinery, tools and raw materials; fabricators and services.


FOURTH FLOOR
MEN
LADIES
OFFICE
STORAGE
EXIT
LADIES LOUNGE
MEN'S ROOM
PHONES
FREIGHT ELEVATOR
FR. EL.
ELEV.
CAPACITY 75,000 LBS
HOSE
4010 4011 4012 4013 4014 4015 4016 4017 4018 4019
4008 4007 4006 4005 4004 4003 4002 4001
4033 4032 4031 4028 4029 4030 4023
4046 4047 4048 4049 4050 4051 4056 4055 4054 4053 4052
4045 4044 4043 4042 4041 4040
4101 4102 4105 4109 4111 4113 4117 4119 4121 4123 4127 4129 4131
(CEILING HEIGHT 4100 AISLE ONLY - 7'-10")
100 AISLE
4103 4104 4106 4108 4110 4112 4114 4116 4118 4120 4122 4124 4125 4126 4128 4130 4132 4133 4134 4135
4201 4203 4205 4207 4209 4211 4213 4215 4216 4217 4219 4221 4225 4227 4229 4231 4233 4235 4239 4241 4242 4243
200 AISLE
4202 4204 4206 4208 4210 4212 4214 4218 4220 4222 4224 4226 4228 4230 4232 4234 4236 4238 4240
4301 4303 4305 4307 4309 4311
4302 4304 4306 4308 4310 4312
4313 4315 4317 4319 4321 4314 4316 4318
4322 4324 4323 4325 4327 4329A 4329B 4326 4328 4330 4331
CHAIRMEN OF THE TECHNICAL SESSIONS
ELEVATORS
BAR
300 AISLE
PLATFORM SCREEN
MARCONI HALL 600 SEATS
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OPEN WELL
STORAGE
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Whom and What to See at the Radio Engineering Show

(Continued from page 277A)

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(Continued on page 282A)

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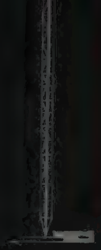
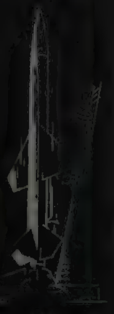


Instruments



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2N1066, 2N1224, 2N1225, 2N1226,
2N1395, 2N1396, 2N1397
2N274, 2N384, 2N1023

1.5 MC   12.5 MC   30 MC   50 MC

HIGH FREQUENCY AMPLIFIER PERFORMANCE

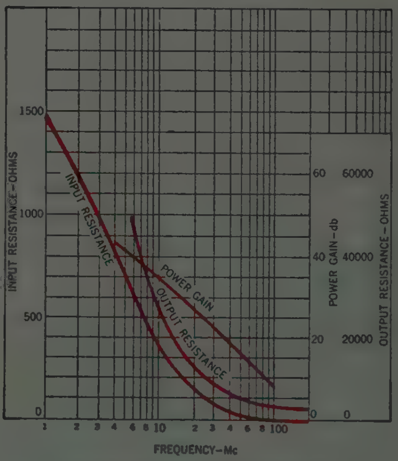
RCA TYPE NUMBERS

h_{fe} 20 to 175 (JEDEC TO-44)	2N1023			2N384			2N274		
h_{fe} 20 to 175 (JEDEC TO-33)	2N1066			2N1225			2N1224		
h_{fe} 50 to 175 (JEDEC TO-33)	2N1397			2N1396			2N1395		
50 Megacycles (sig. freq.)	Min.	Type	Max.	Min.	Type	Max.	Min.	Type	Max.
Common Base Circuit									
Power Gain (db)	18	21	24	15	18	21	—	—	—
Input Resistance (ohms)	—	25	—	—	30	—	—	—	—
Output Resistance (ohms)	—	8,000	—	—	5,000	—	—	—	—
30 Megacycles									
Common Emitter Circuit									
Power Gain (db)	20	23	26	16	20	24	—	—	—
Input Resistance (ohms)	—	100	—	—	50	—	—	—	—
Output Resistance (ohms)	—	8,000	—	—	5,000	—	—	—	—
12.5 Megacycles									
Common Emitter Circuit									
Power Gain (db)	—	—	—	24	28	32	17	22	27
Input Resistance (ohms)	—	—	—	—	250	—	—	150	—
Output Resistance (ohms)	—	—	—	—	16,000	—	—	4,000	—
1.5 Megacycles									
Common Emitter Circuit									
Power Gain (db)	—	—	—	—	—	—	40	45	50
Input Resistance (ohms)	—	—	—	—	—	—	—	1,350	—
Output Resistance (ohms)	—	—	—	—	—	—	—	70,000	—

2N1226—High Voltage Transistor for Video Amplifier and General Instrumentation Service is identical to 2N1224 except maximum collector-to-base and punch-through voltage rating 60v.

RCA Drift Field Transistors can be supplied to meet MIL-S-19500B specifications

Common-Emitter Circuit, Base Input.
Ambient Temperature = 25°C
DC Collector-to-Emitter Volts = −12.
DC Emitter Milliamperes = 1.5.



Performance Characteristics for Types 2N1023, 2N1066, 2N1397

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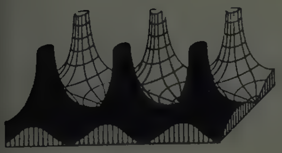
March, 1960
Vol. 48 No. 3
Proceedings of the IRE

Poles and Zeros



Ides Plus Six. The Romans had no name for this date (March twenty-first) but the members of the IRE do. The date marks the beginning of another National Convention and Radio Engineering Show. If the Romans had been fortunate enough to have had such an occasion they would have referred to it as 'dies faustus,' the French would describe it as an 'occasion magnifique,' and Hollywood as a stupendous, colossal, and mammoth extravaganza. In plain English—60,000 serious, earnest, professional people meeting to discuss, to consider, and to see the latest advances in their chosen art is an event of major significance and does not require descriptive hyperboles!

What a program of papers and exhibits! Two hundred and fifty-eight papers will be presented; a rough approximation of the information content based on this number of papers, the length of the presentations, and an estimate of the average reading rate, yields 10 million "bits." Eighty per cent of the production capacity of the electronics industry will be represented by 850 exhibitors, with 1000 plus exhibits, and more than 20,000 items. Fifty-four sessions have been organized with the assistance of the Institute's twenty-eight Professional Groups. This is a vivid demonstration of the importance of the Professional Group structure to the dynamics of the Institute. A careful perusal of the program in this issue is recommended. You will find sessions and features of specific interest.

A Panel Session "Electronics—Out of This World" will be a unique, special feature of the program. The Seminar on the 1959 ITU Geneva Conference will present a panel of high officials from the FCC, the State Department, and ITU. Lloyd V. Berkner, President of Associated Universities, Inc., will address the Annual Meeting.

International once more. From time to time, Poles and Zeros has emphasized (and will undoubtedly continue to emphasize) the international aspects of the IRE. There are 6000 members and 22 sections in 84 countries outside the United States. Convention attendance in 1959 from outside the United States reached 1000, representing 38 different countries. In recognition of the truly international character of the Institute, the Board of Directors in meeting assembled, on January 6, 1959, amended By-Laws Section 701.1 so that hereafter our annual gathering will be known officially as the "IRE *International* Convention and Radio Engineering Show." We welcome the new name as a further step in just recognition of the international scope of the Institute.

Keeping abreast. Our passion for the written word is seldom stated. It behooves all of us to know of the availability of information pertinent to our particular area of interest. In the last several years we have become increasingly aware of the necessity of familiarizing ourselves with what the Russians are publishing. There has been a profusion of translation services attempting to meet this particular need. As an accommodation to the members, therefore, the PROCEEDINGS with this issue is inaugurating a new listing. The sources of the available English translations of the Russian literature, in so far as we are aware of them, will be printed at the end of the Abstracts and References section each month.

While investigating these Russian translation services, the Editor also discovered sources (unknown to him) of information on publications calculated to assist in keeping up-to-date with United States authors as well. This month, therefore, we include, also at the end of the Abstracts and References section, the story of the facilities of the Office of Technical Services of the U. S. Department of Commerce. Each month, OTS provides over 100 new reports of electronics research and development. The reports range through development and application of new or improved transistors, diodes, tubes, amplifiers, circuitry, and antennas, to research on entirely new electronic systems. The reports are the product of research by the Army, Navy, Air Force, Atomic Energy Commission, and other agencies who turn over their unclassified information to OTS for reproduction and distribution. OTS also distributes translations of Russian and other technical literature which it collects from agencies of the Federal Government. Having spoken, we take no responsibility for your failure to read it all!

Know your Institute. On the contents page of each issue of the PROCEEDINGS there will be found the complete list of the officers and directors of the Institute. It seems appropriate to call this to your attention now so that members may become acquainted with the 1960 roster; it appeared for the first time last month and will, of course, continue throughout the year. To further inform the membership on the development of the Institute, appropriate statistics will be published each month. These statistics will summarize the latest membership and other organizational data. This month these statistics will be found on page 14A.

Congratulations to AIP. Distributed as a supplement to the December 1959 issue of "Physics Today," the second edition (1959) of the American Institute of Physics "Style Manual" is an outstanding publication. Scientists and engineers have long been criticized (unjustly, of course) for their ineptness in the literary field. From now on physicists, at least those who study this excellent document and heed its guide lines, will have no excuse for being inept. The manual deals with the preparation of a scientific paper; general style, presentation of mathematical expressions, preparation of illustrations, and other pertinent subjects. It is clearly organized and profusely illustrated. Congratulations to the AIP, and in particular to its Publication Board.—F. H., Jr.

Haraden Pratt

Winner of the IRE Founders Award

Haraden Pratt (A'14–M'17–F'29), Secretary and Past President of the IRE, was born in San Francisco, Calif., on July 18, 1891. He began his radio career as an amateur in 1905, and from 1910 to 1914 was a wireless telegraph operator and installer of equipment for the United Wireless Telegraph Company and Marconi Wireless Telegraph Company of America.

In 1914 he received the B.S. degree in electrical engineering from the University of California, and thereafter became a construction and operating engineer for the Marconi Company's trans-Pacific radio stations in California.

As an Expert Radio Aide for the Navy Department from 1915 to 1920, he was concerned with the construction and maintenance of its high-powered radio stations. In 1920, he began the establishment of the public service radiotelegraph system of the Federal Telegraph Company on the West Coast. In 1925 he constructed and operated a radiotelegraph system between Salt Lake City and Los Angeles for the Western Air Express, the first air mail contractor in the western United States. Later he was in charge of development work on radio aids for air navigation at the National Bureau of Standards. In 1928 he became Chief Engineer, and later Vice-President, of Mackay Radio and Telegraph Company. He constructed its world-wide communication system.

For his work during World War II as Chief of the National Defense Research Committee's Division 13 on Communications, Mr. Pratt was awarded a Presidential Certificate of Merit. Immediately after the war, he became Vice-President and Chief Engineer of the Commercial Cable Company, All America Cables and Radio, Inc., and the American Cable and Radio Corporation. For many years he held offices in other companies of the International Telephone and Telegraph Corporation, but retired from these activities in 1951. In October of that year, he received a Presidential appointment to the newly-created post of Telecommunications Advisor to the President. He has since retired from government service, and more recently has engaged in consulting services. For a period of twenty-four years he was a member of the United States delegations to international radio and telecommunications conferences.

Mr. Pratt is a member of Sigma Xi. As life member of Veteran Wireless Operators Association, he was awarded the Marconi Medal of Achievement in 1951. He is a Fellow of the American Institute of Electrical Engineers and the Radio Club of America, an Associate Fellow of the Institute of the Aeronautical Sciences, and an honorary life member of the IRE, Australia. In 1944, he received the IRE's Medal of Honor.

Harry Nyquist

Winner of the IRE Medal of Honor

Harry Nyquist (A'39–M'47–F'52) was born on December 7, 1889 in Nilsby, Sweden. He attended the University of North Dakota, Grand Forks, from 1912 to 1915 and received the B.S. and M.S. degrees in electrical engineering in 1914 and 1915, respectively. He attended Yale University, New Haven, Conn., from 1915 to 1917, and was awarded the Ph.D. degree in 1917.

From 1917 to 1934 he was employed by the American Telephone and Telegraph Company in the Department of Development and Research Transmission, where he was concerned with studies on telegraph picture and voice transmission. From 1934 to 1954 he was with the Bell Telephone Laboratories, Inc., where he continued in the work of communications engineering, especially in transmission engineering and systems engineering. At the time of his retirement from Bell Telephone Laboratories in 1954, Dr. Nyquist was Assistant Director of Systems Studies.

During his 37 years of service with the Bell System, he received 138 U. S. patents and published twelve technical articles. His many important contributions to the radio art include the first quantitative explanation of thermal noise, signal transmission studies which laid the foundation for modern information theory and data transmission, the invention of the vestigial sideband transmission system now widely-used in television broadcasting, and the well-known Nyquist diagram for determining the stability of feedback systems.

Since his retirement, Dr. Nyquist has been employed as a part time consultant engineer on communication matters by the Department of Defense, Stavid Engineering Inc., and the W. L. Maxson Corporation.

Scanning the Issue

Design Considerations for Integrated Electronic Devices (Wallmark, p. 293)—Integrated electronic devices will probably be the next major step in the evolution of electronics. By incorporating the functions of several components in one tiny solid, it will be possible to achieve packing densities of about 100 million components per cubic foot, resulting in a drastic saving in space and weight. There are, however, a number of practical limitations which will have to be faced. This paper explores the most important present-day difficulty with integrated devices, namely, the decreased number of usable units that are liable to be produced during the fabrication process. This decrease, called shrinkage, is due to the fact that an integrated device is in essence a multi-unit device. If any one of these units is faulty, the whole device will probably have to be discarded. This shrinkage factor, as the author shows, plays a very important role in determining the maximum number of units it is economically feasible to integrate into a single device. The author goes on to develop several methods that will partially reduce this high shrinkage factor to which integrated devices are prone.

Perceptron Simulation Experiments (Rosenblatt, p. 301)—Since 1957 the Cornell Aeronautical Laboratory has been conducting a series of unusual pattern-recognition experiments with a theoretical model of a rudimentary brain, called the perceptron. The perceptron is a simplified, but biologically plausible, net of neural elements which theoretical studies have shown is capable of learning to discriminate and to recognize perceptual patterns. This capability has now been verified and further explored by using a computer to simulate the behavior of the perceptron. The visual stimuli which are generated by an image falling on the retina of an eye are represented by dot patterns which are fed to the computer. The action of every cell and connection in the perceptron brain model is then carried out by the computer. The output response indicates whether or not the input image has been correctly identified. Using alphabetic characters and various geometric shapes as input images, the author ran several interesting experiments designed to study how rapidly and how well the perceptron could 1) be taught and 2) spontaneously learn to discriminate between and recognize different patterns. The results provide valuable data on learning rates and capabilities under various circumstances and provide insight into conditions under which different systems break down or deviate from typical biological learning phenomena. Above all, the experiments go a long way toward demonstrating the feasibility of a perceptron as a pattern-recognizing device.

Pulse Compression—Key to More Efficient Radar Transmission (Cook, p. 310)—Modern military requirements for radar and the advent of radar astronomy have placed much emphasis on methods of increasing the ranges at which objects may be detected. Radar ranges can be extended by increasing average power by means of a wider transmitted pulse, but only with an accompanying, and often unacceptable, sacrifice in range resolving capability. Consequently, designers have turned to stepping up the peak powers of tubes and, further, employing post-detection integration techniques, leading to an inefficient use of tubes and of available average power. This paper discusses an important proposal for increasing the average power capability of a pulse radar without increasing the peak power output of tubes or degrading the pulse resolution. The technique consists of linearly sweeping the carrier frequency of the pulse to be transmitted and of feeding it through a time-delay filter whose frequency characteristics are such as to delay one end of the pulse relative to the other. The result is to compress the width of the pulse and to increase its amplitude, but without exceeding the actual peak power limitations of the system.

Field Effect on Silicon Transistors (Schwartz and Levy, p. 317)—By observing what happens to the alpha of a silicon transistor when dc electrostatic fields of various strength are applied to the surface, the authors have developed a direct method of calculating surface recombination velocity. This work ties surface recombination theory directly to an operating device, making an excellent addition to the literature on field-effect surface studies.

A Half-Watt CW Traveling-Wave Amplifier for the 5–6 Millimeter Band (McDowell, *et al.*, p. 321)—The production of a half watt output over a bandwidth of 10,000 mc centered at 55,000 mc represents a major advance in the state of the millimeter wave art, exceeding previously obtainable output powers in this frequency range by at least ten to one. As the first practical CW power amplifier with broadband performance in the millimeter range, this development has broad implications for the future, especially in connection with the eventual use of circular waveguide systems for very broadband millimeter communications. In addition, the techniques of helix mounting and cooling will be of great interest to tube engineers.

The Propagation of Radio Waves of Frequency Less Than 1 KC (Pierce, p. 329)—This paper is concerned with propagation phenomena that occur at frequencies as low as 100 cps—probably the lowest radio wave frequency that has ever been discussed in the PROCEEDINGS. This represents the low end of a frequency band that is now the center of much attention. The authors have found discrepancies between the observed attenuation of signals in the 100 cps to 1000 cps range arising from lightning discharges and the attenuation predicted by theory, which visualizes propagation at extremely low frequencies as occurring in the fashion of a mode traveling within a waveguide formed by the earth and a concentric ionosphere of constant height. It is shown that the discrepancies may be explained by replacing the constant-height model with an ionosphere which increases in height as frequency decreases. Perhaps equally important, this work shows that further experimental observations are needed at these extremely low frequencies.

Maximum Stable Collector Voltage for Junction Transistors (Schmeltzer, p. 332)—When a transistor is operated at high voltages, its stability may be jeopardized either by current multiplication or thermal heating effects, leading to premature breakdown. The author makes an excellent analysis which takes both effects into account quantitatively, thereby providing a basis for specifying a biasing voltage that is safe. In an example he shows that although the breakdown voltage due to multiplication effects alone is 54 volts, and due to thermal effects alone is 53 volts, the interaction of the two lowers the maximum stable voltage to 37 volts.

Ionospheric Models as an Aid for the Calculation of Ionospheric Propagation Quantities (de Voogt, p. 341)—A large computational program of ionospheric ray tracing on a computer is summarized in this brief, readable paper. The results are given in the form of curves which are very useful to people involved in ionospheric studies and in predicting communication frequencies. Although model calculations of this sort are not new, this paper is particularly interesting because it uses fresh models much more in line with what we now know about the distribution of electron density in the ionosphere from rocket investigation.

Electromagnetic Properties of High-Temperature Air (Bachynski, *et al.*, p. 347)—This paper gives an interesting summary of the electromagnetic properties of air at high temperatures and, as an illustrative application of the theory, an estimate is made of the attenuation and phase delay of radio waves from a hypersonic vehicle at various speeds and altitudes in space.

Scanning the Transactions appears on page 411.

Design Considerations for Integrated Electronic Devices*

J. T. WALLMARK†

Summary—Some fundamental factors affecting the design of integrated electronic devices are discussed, particularly the influence of shrinkage. It is concluded that the considerable advantages of integrated devices, compared to conventional devices, such as very small volume and weight, and reduced number of metallic connections, have to be paid for by higher shrinkage in fabrication. Three considerations are advanced, which will reduce partially this higher shrinkage. First, the resulting increase in cost may be made very small if the design of the integrated device allows the extent of integration to be adjusted to the shrinkage rate. Second, the resultant high cost of the integrated device justifies a higher investment in the fabrication process of the integrated devices than for the individual units. Third, methods of doctoring integrated devices may be used to reduce the shrinkage effectively.

I. Description of Integrated Semiconductor Devices

A. Specific Examples, Shift Register and Unipolar Transistor Logic

LET us first consider some practical embodiments of integrated devices. By an integrated device or circuit is meant, following the generally accepted terminology,[1] a device consisting of one piece of solid into which have been integrated several component functions, active as well as passive, without external interconnections.[2–5] Two recently developed constructions will be used as examples, namely an *integrated shift register*[4] and the integrated *direct-coupled* unipolar transistor logic.[5]

The *integrated shift register* which is shown in Fig. 1 consists of a number of bistable stages, each similar to a thyristor.[6] The individual stages are interconnected by small sections of semiconductor, each serving as a delay line. Each stage has a load resistance in series, and may be in either of two stable states; ON, corresponding to a high current in the stage, or OFF, corresponding to a low current in the stage. These states may be propagated along the bar by the application of a shift voltage to the two end contacts. In this manner, a binary number, stored in the register, may be shifted through the register. Each stage is also provided with a base contact for write-in of information. The semiconductor bar between the stages stores the minority carriers during the shift process and serves as a short-time memory. This function is usually carried out by RC circuits in conventional registers. In effect, therefore, the circuits connecting the different stages have been integrated into the device. The delay line itself would be characterized, according to the generally accepted terminology,[1] as a functional device. A functional device uses an electronic phenomenon, in this case minority carrier transfer, to accomplish a circuit function. Thus the components integrated in a functional device cannot be separated.

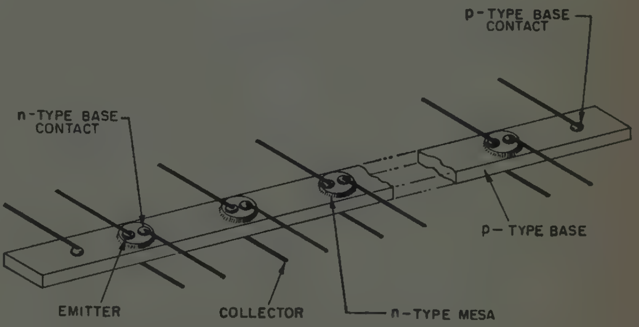


Fig. 1—Integrated shift register.

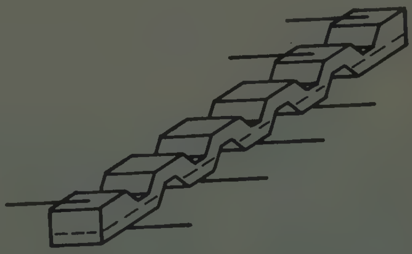


Fig. 2—Multiple AND gate using direct-coupled unipolar transistor logic.

Another integrated device, namely a multiple AND circuit using *direct-coupled unipolar transistor logic* is shown in Fig. 2. It consists of five unipolar transistor elements fabricated in one piece of silicon, four of which serve active device functions, while the fifth performs a passive component function, in this case that of a resistor. A voltage applied to the end contacts results in a current through the silicon bar and, consequently, an output signal if all the four gate-regions are simultaneously, and only slightly, reverse-biased. If, on the other hand, one or more of the gate regions are strongly reverse-biased, no current will flow along the bar and no output signal is obtained. The use of unipolar transistors makes possible the construction of a large variety of different computer circuits in integrated form.

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* Original manuscript received by the IRE, August 6, 1959; revised manuscript received, December 10, 1959. Sponsored by Air Force Cambridge Res. Center, Electronics Res. Directorate, under Contract No. AF19(604)-1957.

† RCA Labs., Princeton, N. J.

[1] As used by I. M. Ross in a review "Functional Devices," at the Electron Devices Meeting, Washington, D. C.; October 29–31, 1959.

[2] L. A. D'Asaro, "A stepping transistor element," 1959 WESCON CONVENTION RECORD, pt. 3, pp. 37–42.

[3] J. S. Kilby, "Semiconductor solid circuits," *Electronics*, vol. 32, pp. 110–111; August 7, 1959.

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B. *Characteristic Features of Integrated Devices*

The main advantage of integrated devices is a considerable saving in space and weight. The devices described above have a packing density of about 10^8 components per cubic foot. This very large packing density results not only from the integrated device technique proper, but also from the assembly of a large number of bare, nonencapsulated units and circuits within the same enclosure, from the incorporation of printed circuit techniques even in the device itself, from sandwiching such printed circuits, and from standardizing the active and passive components to identical shape and size.

In this way, it has been possible to approach miniaturization in a functional manner, reminding one of the functional trend in architecture some 30 years ago. Nonfunctional details, such as air-spaces between elements and excess semiconductor, have been reduced to a bare minimum. Structural support, which usually has to be provided to all parts, *e.g.*, the connecting wires, is supplied by the semiconductor and the insulator wafers with simultaneous electrical, and sometimes encapsulating, functions. Internal metallic connections are eliminated, or may be reduced to minimal cross sections dictated only by electrical requirements. An illustration of this tight packing is given in Fig. 3, which contrasts a bistable stage of 1948 with a similar stage of 1958 and a similar stage plus delay line in integrated form. (Some of the reduction in size is obtained by simplified, and therefore more critical, operation in the last-mentioned case. Also, encapsulation is not shown.)

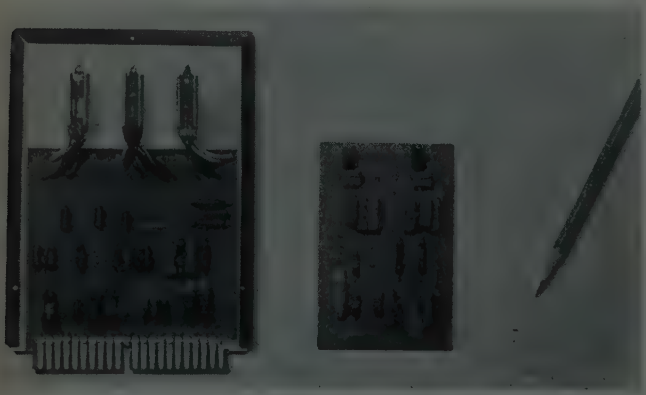


Fig. 3—Left, bistable stage as made in 1948; center, bistable stage as made in 1958; right, bistable stage and delay line in integrated design (at pencil point).

II. Limitations of Integrated Devices

A. *Physical Size Limitation*

Now let us turn to some of the limitations of integrated devices. The first is a rather practical one, namely that of physical size or packing density. The packing density of some existing electronic components and some simple systems is shown in Fig. 4. It is assumed that the components are packed as densely as possible, and that leads, tube pins, etc., are disregarded. The smallest single component commercially available at the present time is the miniature resistor, and it is very unlikely that much smaller individual components would be made even if this were technically possible. In the miniature resistors, the leads constitute approximately 50 per cent of the volume, and they are difficult to handle in their present form, *e.g.*, picking them up from a flat surface without the help of tweezers, etc. Clearly, there must be a point of diminishing return, where future reduction in size makes it impractical to handle each individual component without adding some form of handle, for instance in the form of leads. When these handles become the largest part of the component, further reduction in size appears pointless.

One way out of this dilemma of not being able to reduce the size of components for loss of handling ability, is to use the components in groups, arrays or sheets, combining several elements into superstructures which then are of such a size that they can be handled. For a moderate number of elements, this represents the middle area in Fig. 4. The integrated devices described in this article fall in this domain.

Extending the argument still further, there must be a limit at which even arrays of moderate complexity become so small that they again cannot be handled without special tools. Beyond this comes an area, corresponding to the top part of Fig. 4, where it is not possible to handle less than an entire system, unless special tools, as yet completely unknown to electronic manufacturing, are used. It is not surprising to find the human brain in this category, and it may be illuminating to think of the difficulties encountered in experimental studies of the electronic activities of the brain in order to appreciate the breakthroughs needed to make sensible use of a packing density exceeding that of the brain. It appears that, for the foreseeable future, the human brain represents a ceiling for packing density which will not likely be surpassed with any presently-envisaged technique.

Another factor to consider in designing microminiature electronic systems is the relative volume efficiency of electronic components, which is illustrated in Fig. 5. The figure shows the ratio of electronically active volume to total volume for some common electronic components. In order to bring this figure close to one, encapsulation of single components must be discarded in favor of encapsulation of circuits or entire systems, mechanical support must be minimized or shared, etc.

B. Temperature Limitation

Now let us turn to the limitation on packing density imposed by heat dissipation. In a binary computer application all the elements would be either ON or OFF at all times. In the most unfavorable case, all the elements would be ON, in which case the power per element may typically be 0.01 watt. The temperature in a sphere consisting of identical elements with volume d^3, each developing P watts, is given by

$$\theta = \theta_0 + \frac{P(R^2 - r^2)}{6\lambda d^3}, \tag{1}$$

where

θ is the temperature at radius r,
θ_0 is the temperature at the surface at radius R,
λ is the heat conductivity.

For integrated devices, consisting of layers of semiconductor between printed circuit ceramic wafers, the heat conductivity would be a compromise between that of air (0.025 w/m C°), that of semiconductor (Si 148 w/m C°, Ge 58 w/m C°), that of ceramic (≈ 2 w/m C°) and that of metal (Sn 65 w/m C°). A fair estimate of the resulting heat conductivity may be 1 w/m C°. With silicon, $\theta_0 = 50°\text{C}$, $\theta_{\max} = 175°\text{C}$, $d = 5 \times 10^{-4}$ m, R is obtained as 3×10^{-3} m corresponding to 6 layers or about 200 elements.

This may also be seen from Fig. 6, which shows the number of elements in a sphere N vs P, with d and R as parameters. Although there are well-known methods to raise this temperature limitation considerably, such as the use of high band-gap semiconductors (gallium arsenide, indium phosphide, etc.), design of the devices with a high surface-to-volume ratio to allow more efficient cooling, etc., it appears advantageous from a heat-conduction point of view to limit the size of integrated

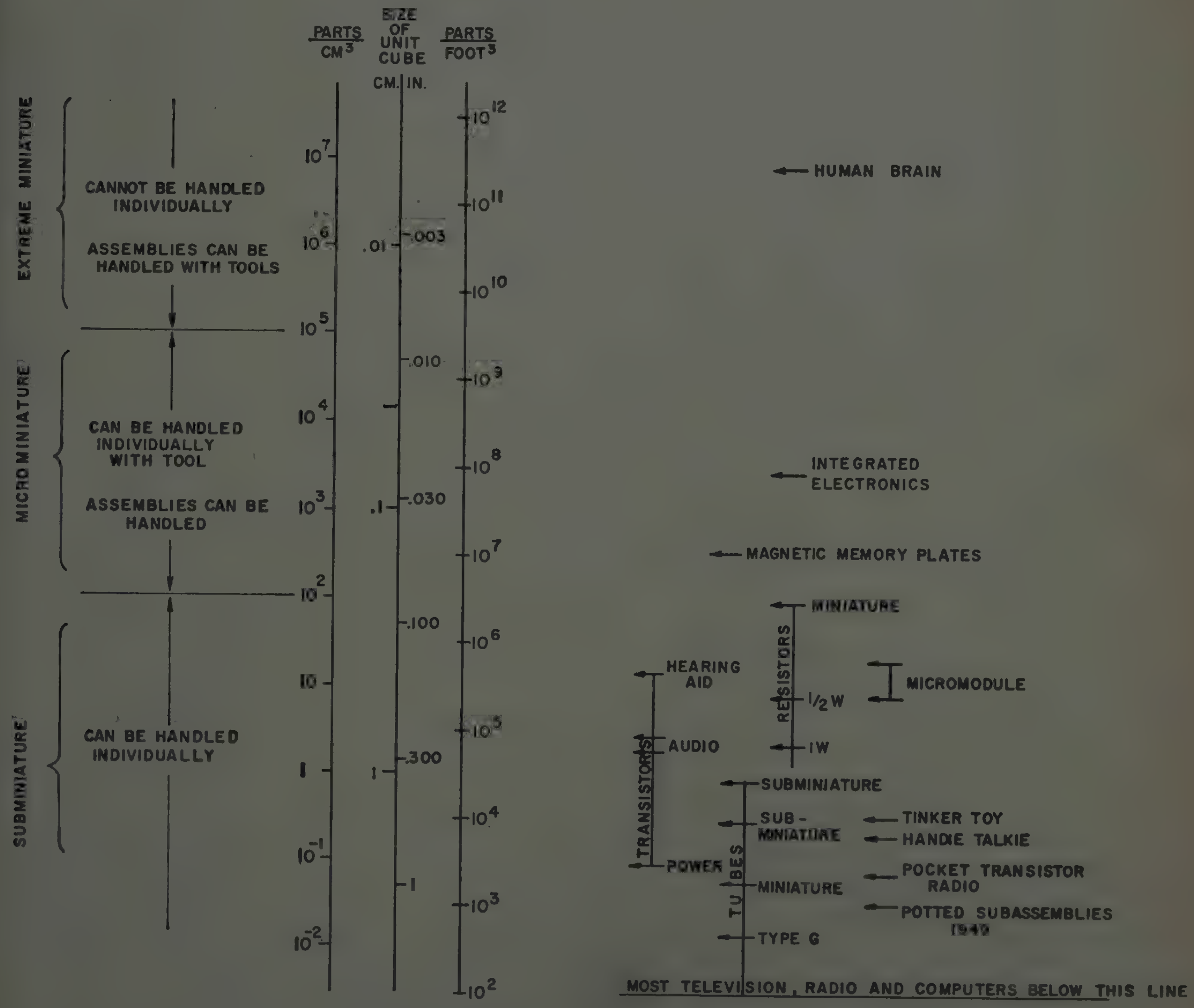


Fig. 4—Packing density of electronic components.

devices to some reasonable number of stages. A size of the order of 100 stages seems within reason.

Heat dissipation therefore presents a real limitation on the packing density of integrated devices, and the high packing density of 10^8 stages per cubic foot cannot be maintained over a volume of, for example, one cubic foot with the devices described unless special precautions are taken. For spherical symmetry, the volume-to-surface ratio goes up linearly with size of the integrated device. The larger the device, the lower the packing density has to be.

While the limitation of physical size and that of temperature may be expected to cause trouble at the higher packing densities of future devices, the next limitation to be investigated is felt already in present devices. This is the limitation caused by the probability of errors in the fabrication process leading to shrinkage, and will be treated in the next section.

III. Shrinkage Considerations

A. *Influence of Shrinkage Rate*

As will be shown in this section, the main difficulty with integrated devices is sensitivity to shrinkage in the fabrication process. The reason for this is that, as a rule, each of the units in an integrated device must function properly. Thus the rejection of a few inferior or faulty units out of a group, which is possible when individual units are used, is seldom possible in the case of integrated devices, and the entire unit may have to be discarded. An analysis of this situation shows that, for an integrated device to be competitive, the shrinkage per component should not exceed a limit which depends on the number of components and the way in which they are combined. This requirement in general is rather stringent.

For the purpose of comparison between individual units and integrated devices, shrinkage may be divided into two main categories. The first category is shrinkage caused by *uncorrelated accidents*. Here the chance that a unit is lost is independent of what happens to other units. Such accidents may be the breaking of a wafer, dropping a unit on the floor, contaminants on a unit, etc. The second category is shrinkage caused by *correlated accidents*. Here the fate of one unit is the same as, or related to, that of other units. Such accidents may be the dropping of a batch on the floor, faulty raw material affecting many units, operator inability, etc. Shrinkage falling in the second category affects individual units and integrated devices equally in the limit when all units in a batch are rendered useless and will be neglected as a favorable case giving no excess cost of integrated devices. Shrinkage falling in the first category, however, represents the worst possible case with regard to integrated devices, and will therefore be considered in detail. In reality, shrinkage is a compromise between these two extremes.

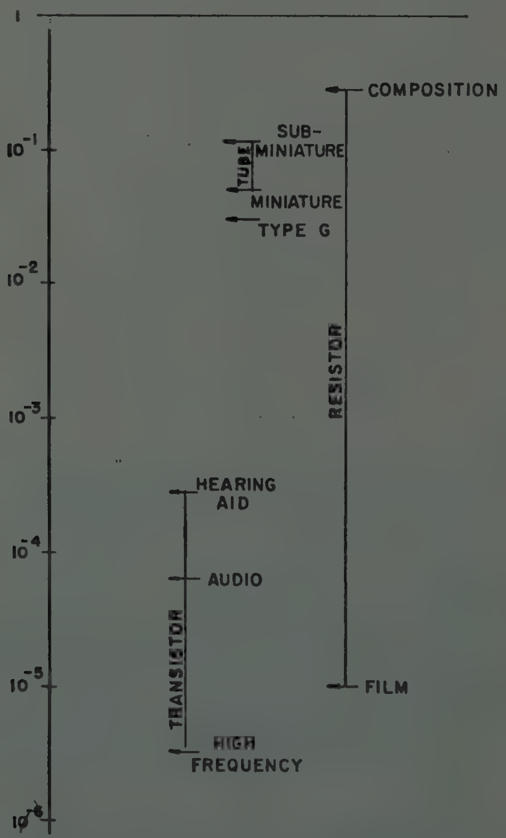


Fig. 5—Ratios of active to total volume for typical electronic components.

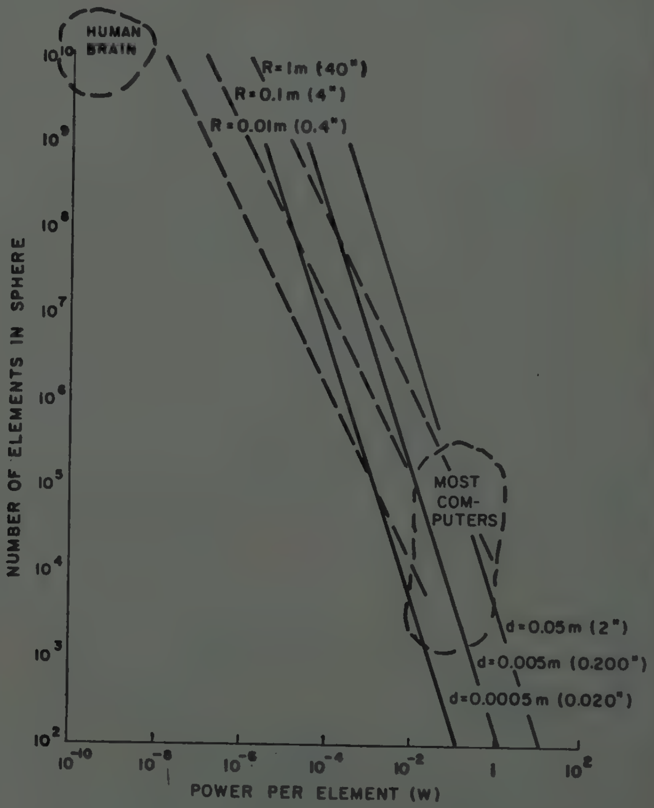


Fig. 6—Size-power relationship for direct-coupled unipolar silicon transistor logic.

A completely general treatment would assume an arbitrary correlation coefficient, c_f, where $0<c_f<1$. Here $c_f=0$ corresponds to the first category and $c_f=1$ to the second category mentioned above. However, lacking this general treatment, let us investigate the worst possible case corresponding to $c_f=0$.

Let us assume that an integrated device offers such advantages that its cost may be larger than that of its corresponding assembly of individual units, by a factor F, where $F\geqq 1$. Then the shrinkage of the integrated device may be allowed to reach, but should not exceed, $(F-1/F)\times 100$ per cent.

Consider now as an example, a shift register, and compare an N-stage device of this type with an assembly of N individual active devices. Let us disregard the passive components for a first approximation. Assume that the integrated device has a shrinkage such that S out of every 100 stages cannot be used. Then the yield of complete integrated devices, Y_i, is

$$Y_i = (1 - S/100)^N \times 100 \text{ per cent.} \qquad (2)$$

For the individual units assembly, it is fair to assume the same shrinkage per unit. With no shrinkage in the assembling process, the yield of subassemblies, Y_s, is

$$Y_s = (1 - S/100) \times 100 \text{ per cent.} \qquad (3)$$

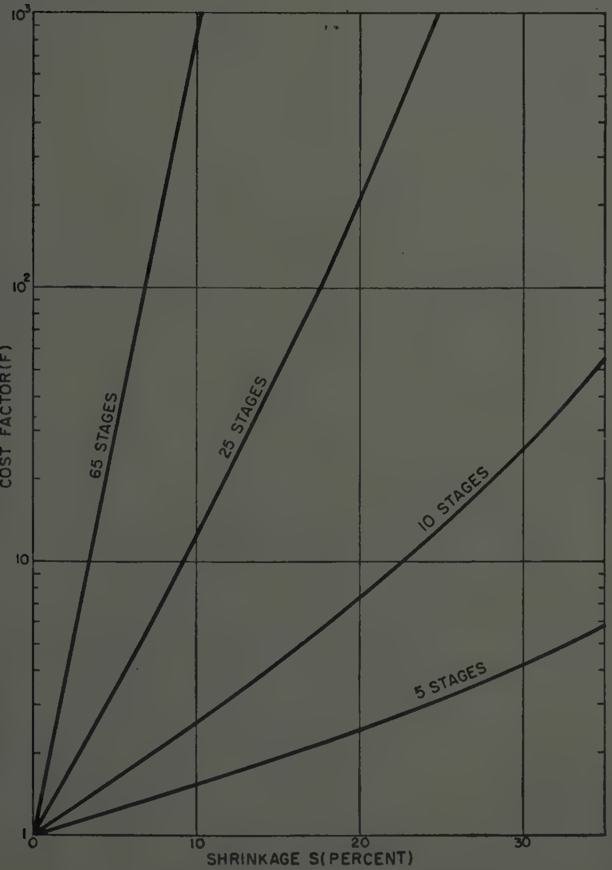


Fig. 7—Cost factor of integrated device vs shrinkage in fabrication of individual units.

Making up for the lower yield of integrated devices by F times higher cost gives

$$Y_i/Y_s = (1 - S/100)^{N-1} = 1/F, \qquad (4)$$

or

$$F = (1 - S/100)^{1-N}. \qquad (5)$$

In Fig. 7 are shown some values of S and N of practical interest, and corresponding values of F are computed from (4). As an example, it can be seen from the curves that the cost of a 10-stage integrated unit is 7 times that of an assembly of ten individual units when the shrinkage on the fabrication process amounts to 20 per cent. However, for large shrinkage, the cost of any but the smallest number of stages probably is prohibitive for most applications.

Shrinkage is a phenomenon that is seldom constant but may vary up and down from some long-time average value. For a comparison, the long-term average value of F may be computed from a summing up of yields over the entire period,

$$1/F = \sum_p 1/F_p, \qquad (6)$$

where F_p is the cost factor for a certain part of the period considered.

For a particular application, such as satellite instrumentation, the small size of an integrated device may allow a cost that is, for example, 1.5–5 times that of an assembly of individual units. The maximum number of stages that may then be economically used in each integrated device is shown in Fig. 8. This number decreases extremely rapidly with shrinkage.

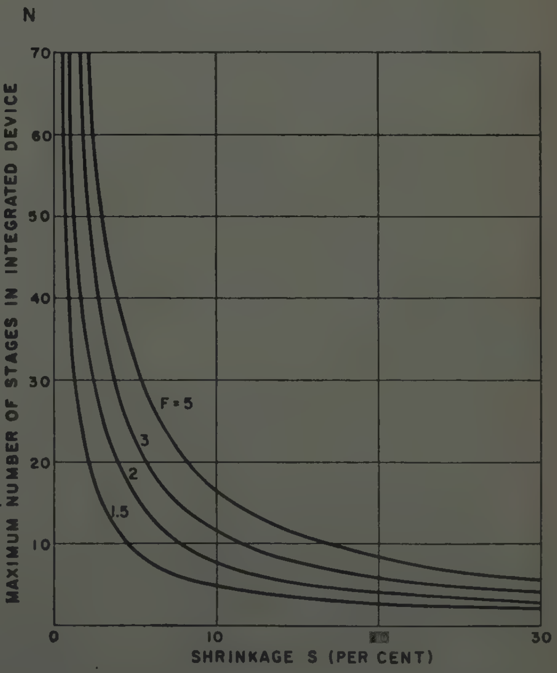


Fig. 8—Maximum number of stages in an integrated device vs shrinkage. Cost-factor parameter.

It seems therefore that an important requirement for integrated devices is a manufacturing process with a sufficiently low shrinkage. A somewhat higher investment in the fabrication equipment for integrated devices, compared to that for individual units, is justified because of the higher cost of shrinkage for the former.

This is illustrated in Fig. 9. Here the fabrication cost has been divided into two parts, one part consisting of investment in the fabrication process, which is independent of the number of units made. Such costs would be research and development, acquisition of machines, improvements in the process, automation, etc. The other part is processing cost which is directly proportional to the number of units made. Such costs are materials and labor. Of these two costs, F_1 varies with shrinkage as shown in Fig. 7. For F_2 let us make the simple assumption

$$S = 1/(F_2 + 1). \qquad (7)$$

This means that S can be reduced arbitrarily by spending more on F_2, as is found in practice. The boundary values are

$$S \rightarrow 0 \quad \text{when} \quad F_1 \rightarrow \infty,$$

$$S \rightarrow 1 \quad \text{when} \quad F_2 \rightarrow 0,$$

again in agreement with practice.

Plotting F_2 along the abscissa and using the relations (5) and (7) gives the dashed lines in Fig. 9. The straight line for the investment cost has been given a slope corresponding to a certain number of units fabricated. The resultant total cost is shown in solid lines.

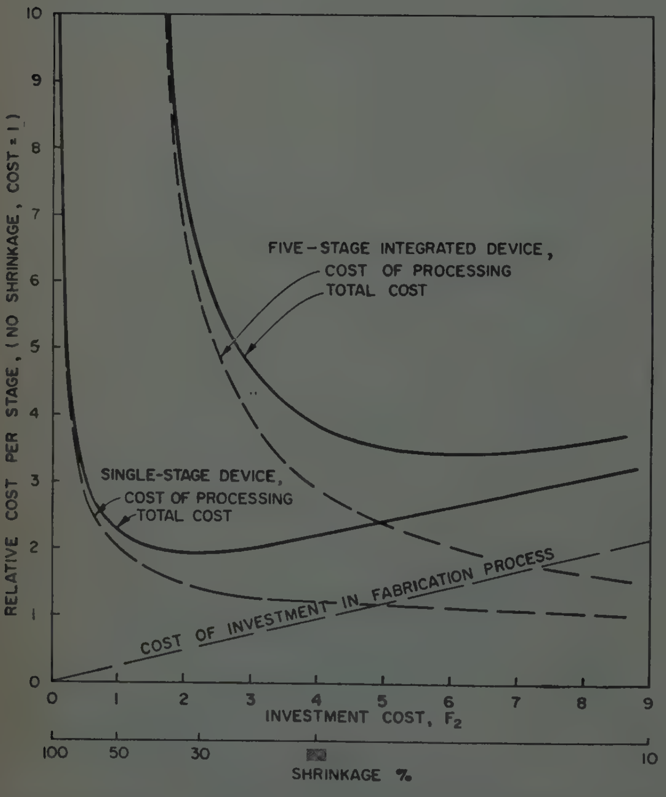
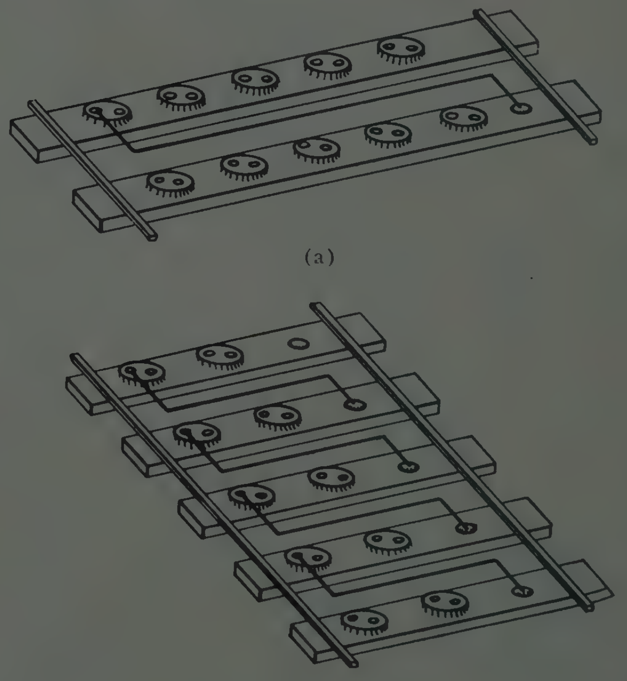


Fig. 9—Relative cost of single device and 5-stage integrated device vs investment in fabrication process.

The total cost per stage for single devices shows a minimum which is the optimum point for fabrication of conventional devices. At this point, corresponding to a shrinkage of approximately 30 per cent and a fairly low investment, the cost of a five-stage integrated device is very large. Increasing the investment in the fabrication method, however, sharply reduces the total cost for the integrated device until a minimum, representing the optimum point for fabrication of integrated devices, is reached at a higher investment. Although this mathematically exact treatment represents an oversimplification of the practical situation, it is qualitatively correct.

Furthermore, it is desirable that the integrated device be designed so that the extent of integration—the number of components that are integrated into one piece of semiconductor—is flexible and adjusted to the particular shrinkage rate at any one time. An example is illustrated in Fig. 10.

For many semiconductor devices at the present time, the over-all shrinkage may well amount to 30 per cent. This figure, however, usually includes some correlated shrinkage and corresponds to a somewhat lower figure in Fig. 8, say approximately 15 per cent. For most commercial electronic equipment used at the present time, cost of a miniature version may not often exceed 5 times that of a conventional version. Then the maximum amount of integration should not exceed some ten stages. Shrinkage, therefore, represents, at the present time, the most stringent limitation on integrated device design.



(a)

(b)

Fig. 10—Two integrated devices with identical cost factor $F = 1.5$. (a) $S = 10$ per cent. (b) $S = 30$ per cent.

B. Shrinkage Reduction by Reserve Stages

Several methods may be thought of to reduce the influence of shrinkage. One such method would be to improve the faulty stages by means such as selective etching to remove weak parts of a junction, sandblasting to increase surface recombination over a small area, replacing broken leads, etc. However, this requires diagnosis and choice of correct doctoring method, something that can be done only by skilled labor and which would therefore be costly. Another method, and one that is well-adapted to routine operation, is that of reserve stages. This method will be considered in this section.

As an illustration consider a shift register such as the one shown in Fig. 1. The yield of units with ten good stages, Y_{10}, the yield of units with 9 good stages, Y_9, etc., is obtained from

$$Y_n = (1 - S/100)^N (S/100)^{10-N} \frac{\underline{\lvert 10} - n}{\underline{\lvert n}}, \qquad (8)$$

where n is the number of good stages. These yields for different values of shrinkage are shown in Fig. 11. For 0 per cent shrinkage, the yield of 10-stage units is, of course, 100 per cent, and for higher shrinkage, the yield is pushed continuously towards units with fewer and fewer stages. Let us assume that the completed register should have 10 good stages. Suppose that in designing the device two extra stages are added, making 12 in all. After the devices are completed, but not encapsulated, they are tested and, in all the devices with one faulty stage, the base contacts of the adjacent stages are connected. This insures that when one of those stages goes ON, its base contact will turn on the other one in the pair simultaneously, thus bypassing the faulty stage. This scheme may be extended to still further stages so that with a 16-stage device, 3 faulty stages may be bypassed, etc. However, the addition of extra stages, of course, increases the shrinkage as shown in Fig. 7, and finally an optimum is reached.

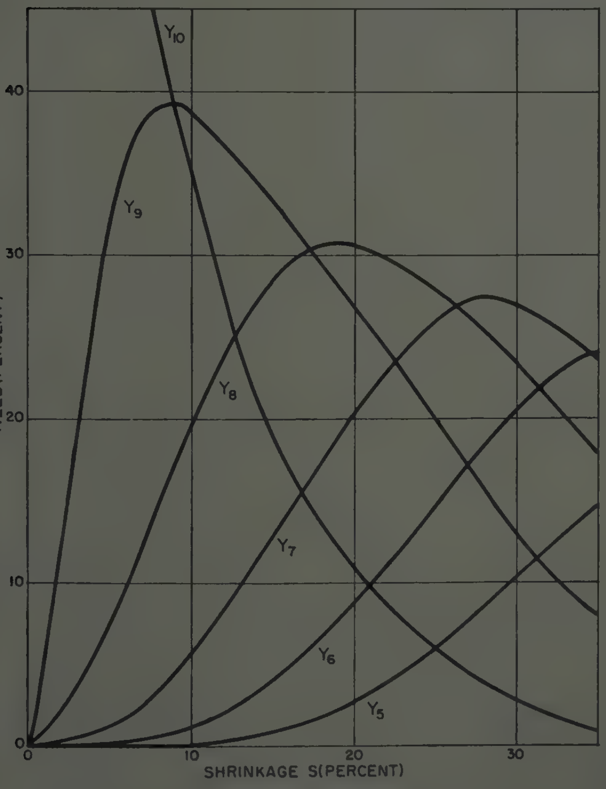


Fig. 11—Yield of integrated units with 10, 9, 8, etc., good stages vs shrinkage in fabrication of individual stages.

The same method is applicable to other forms of integrated devices. In the case of the multiple AND gate, shown in Fig. 2, a metallic connection may be introduced from the source of one unit to the drain on the unit on the other side of the faulty stage, thus effectively bypassing the faulty stage.

Assume that the cost of bypassing a faulty stage is 10 per cent of that of making a new device. Further assume that the bypassing has no shrinkage. Then the cost factor becomes

$$F = \frac{(1 - S/100)\left[1 + \frac{1}{10}\sum_1^m \frac{Y_m}{100}\right]}{(1 - S/100)^N + \sum_1^m (1 - S/100)^m Y_m}, \qquad (9)$$

where Y_m is the relative yield of units with m stages faulty and N is now the total number of stages:

$$N = 10 + 2m.$$

For the case in which the bypassing has the same shrinkage rate as the main manufacturing process, the cost factor becomes

$$F = \frac{(1 - S/100)\left[1 + \frac{1}{10}\sum_1^m \frac{Y_m}{100}\right]}{(1 - S/100)^N + \sum_1^m Y_m}. \qquad (10)$$

These expressions are shown graphically in Figs. 12 and 13. Although these assumptions may represent an oversimplification, and though other assumptions may alter the cost factor somewhat, the trend is clear. *By providing reserve stages and using them to bypass faulty stages in the fabrication procedure, a considerable reduction in shrinkage can be accomplished. It appears that a design that facilitates doctoring of this type would be desirable in the fabrication of integrated devices.*

While this method of bypassing is applicable to many integrated devices, it is not as useful in integrated devices involving matrices. Here the bypassing of one element may throw out not only the element but the complete row of which this element was a part, the column of which the element was a part, and also in some cases the corresponding rows and columns of matrices and whatever other devices would be combined with them. To limit the damage caused by a faulty element, it may be necessary to remove it and introduce a new intact element. Such a removal could be accomplished by a lapping or grinding operation which either pulverized or cut out the element. Subsequently, a new element could be put in place and suitably connected. Again, this operation, once worked out and suitably tooled, does not require engineering labor. However, this method assumes elements of such a large size that they may be handled individually.

C. Repair of Integrated Devices

Although it is entirely possible to integrate into one single device, or package, the main part of a computer, for example, the extent to which integration should be carried would be limited by logistic considerations. Assume that one element of the computer started to malfunction after a certain time. Then it is desirable to repair the computer by exchanging a certain part, but usually not the entire computer. The manner in which the computer should be departmentalized to facilitate and minimize the cost of repair would have to be determined by logistic considerations. This requires knowledge about the mean time between failures, and therefore cannot yet be done with confidence. However, even from this point of view, a limit below 100 stages in one department of the device appears reasonable.

IV. OTHER FACTORS THAT INFLUENCE AN EVALUATION

Many other factors have been suggested that would affect an evaluation of integrated devices, such as cost of encapsulating a large unit compared to many small units, the utilization of large but faulty integrated devices for the fabrication of several smaller units, etc. It appears, however, that at the same time as they seem less fundamental than the shrinkage rate, they are also less amenable to a rigorous analysis and therefore will be omitted here. Also omitted will be factors that are characteristic of a specific device or a specific fabrication method.

While in theory it is possible to make almost any communication circuit into an integrated device, it is most easily realized in the case of iterated stages of identical construction, which give very simple operation such as the ON-OFF circuits of digital computers and automation equipment. Also the very large numbers of such circuits used make the gain in weight and space worthwhile. The higher cost of integrated devices, compared to assemblies of individual units, suggests the application to those in which there is a sufficient premium on weight and space. This is usually the case in mobile installations, particularly military installations, and it is here that integrated devices are most needed. However, in the long run it is believed that microminiature electronic systems have a more important function in bringing to a manageable size the complex equipment needed to relieve man from routine mental labor of all types.

ACKNOWLEDGMENT

Many stimulating discussions with S. M. Marcus are gratefully acknowledged.

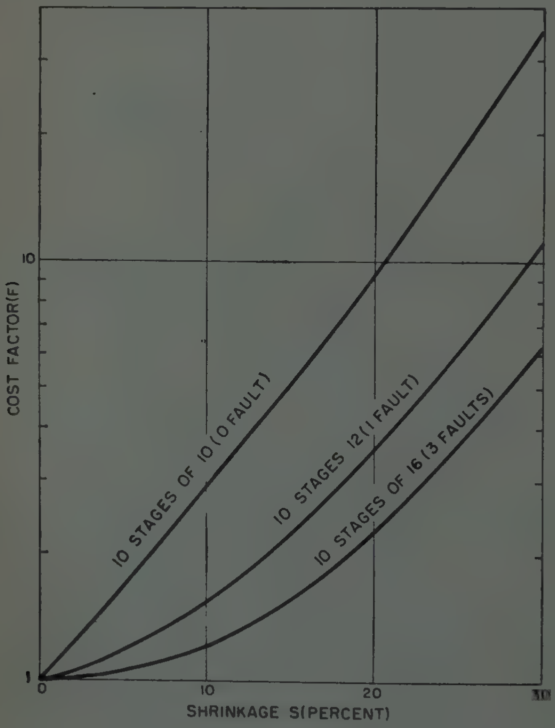


Fig. 12—Cost factor of a doctored 10-stage integrated device vs shrinkage. Shrinkage in doctoring equal to over-all shrinkage.

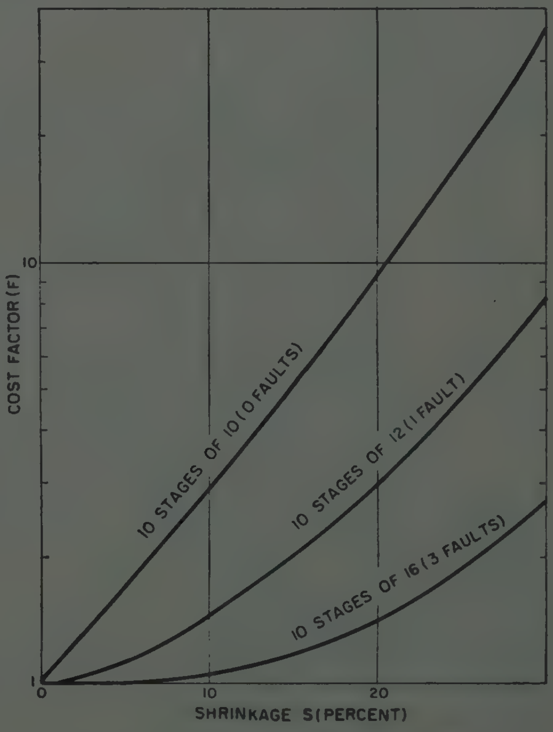


Fig. 13—Cost factor of a doctored 10-stage integrated device vs shrinkage. Shrinkage in doctoring negligible.

Perceptron Simulation Experiments*

FRANK ROSENBLATT†

***Summary*—An experimental simulation program, which has been in progress at the Cornell Aeronautical Laboratory since 1957, is described. This program uses the IBM 704 computer to simulate perceptual learning, recognition, and spontaneous classification of visual stimuli in the perceptron, a theoretical brain model which has been described elsewhere. The paper includes a brief review of the organization of simple perceptrons, and theoretically predicted performance curves are compared with those obtained from the simulation programs, in several types of experiments, designed to study "forced" and "spontaneous" learning of pattern discriminations.**

INTRODUCTION

A NUMBER of papers and reports have been published describing the theory of a new brain model called the perceptron. The perceptron is a minimally constrained "nerve net" consisting of logically simplified neural elements, which has been shown to be capable of learning to discriminate and to recognize perceptual patterns [5]–[8]. This paper is concerned with a report of digital simulation experiments which have been carried out on the perceptron, using the IBM 704 computer at the Cornell Aeronautical Laboratory. These experiments are intended to demonstrate the performance of particular systems in typical environmental situations, free from any approximations which have been used in the previously published mathematical analyses. In the simulation programs, the action of every cell and every connection in the network is represented in detail, and visual stimuli are represented by dot patterns corresponding to illuminated points in a retinal mosaic.

Several related experiments have been conducted previously, using a digital computer for the simulation of a nerve net in learning experiments [1], [2], [4]. Rochester and associates, at IBM, have reported on several attempts to simulate the formation of "cell assemblies," in a model based on the work of Hebb [3] Hebb proposes that a set of neurons which is repeatedly activated by a particular sensory stimulus becomes organized into a functional unit, which can be triggered as a whole by sensory patterns sufficiently similar to the original one. Hebb's book, however, does not attempt to specify in a rigorous manner the exact organization or parameters under which the predicted effects would be obtained, so that the IBM group found it necessary to improvise several models and variations of their own, having various degrees of biological plausibility, in an attempt to construct a definite system. The results of these experiments seem ambiguous, not only because of the uncertain relationship of the final model to the nerve net originally suggested, but also because the phenomenon which was sought after has never been defined in a fashion precise enough so that one might say whether or not it has actually occurred. These experiments illustrate the importance of selecting a suitable measure of performance in work of this type; it is essential that a clearly defined test should be specified for the "learning" which has presumably taken place, or else it is impossible to say either how well a particular system has performed or to compare its performance with any other system, or class of systems, in a systematic fashion.

From this standpoint, the experiments reported by Farley and Clark [1], [2] seem to have been better conceived. In this model, a network of eight randomly connected neurons was simulated. Inputs consisted of stimuli applied to one of two disjunct pairs of "input cells," and outputs were measured as the activity of two pairs of "output cells." In later experiments, the size of the network was increased to sixteen cells. It was demonstrated that this system can learn to favor the output from one set of output cells following the presentation of one of the two stimuli, and the alternative output set following presentation of the other stimulus. The problem of generalization was considered only in terms of relatively slight displacements or alterations of the stimulus patterns, and it was suggested that, under these conditions, the response would be most likely to occur which was previously associated to the stimulus having the greatest overlap with the altered stimulus. The problem of generalization to similar but completely disjunct stimuli was not specifically considered. Nonetheless, the process of generalization advocated as a result of these experiments has much in common with our early work on the perceptron. A more thorough consideration of this problem will be published elsewhere [8].

The design of a simulation program for studies of pattern recognition and perceptual generalization in nerve nets should fulfill at least three basic conditions, each of which has been ignored too frequently in previous work along these lines.

1) Simulation should not, in general, be attempted without a theoretical analysis of the nerve net in question, sufficient to indicate suitable parameters and rules of organization, and to indicate questions of theoretical interest. The examination of arbitrary networks in the hope that they will yield something interesting, or the simulation of networks which have been specially designed to compute a particular function by a definite algorithmic procedure seem to be about equally lacking in value.

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* Original manuscript received by the IRE, July 16, 1959; revised manuscript received, December 14, 1959. This paper was presented at the 1959 IRE National Convention. The work was supported by the Information Systems Branch, Office of Naval Research, under Contract no. Nonr-2831(00), since July, 1957.

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2) Suitable measures of performance must be defined. This means that some task must be set for the system, the outcome of which can be clearly recognized, and, preferably, counted or quantified in some manner. Signal strengths, waiting times for achievement of a criterion, or percentage of correct decisions are examples of suitable measures.

3) Experiments should be designed with suitable controls against trivial or ambiguous results. If we are interested in teaching a device to generalize a response to visual forms, for example, it is essential that a discrimination test should be made involving at least two different responses, to make sure that the system has not simply generalized the desired response universally to all stimuli, regardless of their similarity to one another. Moreover, it is often important to make sure that the cue for the response is the actual *form* of the stimulus, rather than its location on the retina, or some other unintentional source of information. This last condition is often quite tricky to satisfy, and in most of our current work we make use of Born-von Kármán boundary conditions (in which patterns shifted off of one edge of a retinal field re-enter on the opposite side, as in a toroidally connected space) in order to guarantee the logical equivalence of all points in the retinal space. Given such a retinal field, it is sufficient to place each stimulus pattern with equal probability or frequency at all possible locations in the retinal space, in order to guarantee that the illumination of a particular retinal point does not convey any information about which stimulus is present. It should be noted that this condition is not always observed in the experiments reported in this paper, stimuli often being confined to some subfield of the retina in order to increase the rate of learning. In at least one case (the experiment with the "continuous transducer perceptron" shown in Fig. 8) a discrimination has thus been obtained which would not hold up if the field were uniformly covered with the stimulus patterns.

Organization of a Perceptron

Any perceptron, or nerve net, consists of a network of "cells," or signal generating units, and connections between them. The perceptron is defined by two sets of rules: 1) a set of rules specifying the topological constraints upon the network organization, such as the number of connections to a given unit, or the direction in which connections are made, and 2) a set of rules specifying the dynamic properties of the system, such as thresholds, signal strengths, and memory functions. A "fully random network" would be one in which only the number of cells and the number of connections is specified, each connection being equally likely to originate or terminate on any cell of the system. The topological rules for the organization of a perceptron take the form of constraints applied to such a random network, and it is assumed that all connection properties other than those specified remain "random," in the sense just indicated.

A simplified version of the known features of a mammalian visual system is shown in Fig. 1, for a comparison with the organization of a perceptron, which will be described presently. At the extreme left we see a mosaic of light-sensitive points, or retina, from which signals are transmitted to the visual projection area, in the cerebral cortex. Several intermediate relay stations exist in a typical biological system, which are not shown here. These connections preserve topological characteristics of the stimulus in a reasonably intact form. Beyond the projection area, however, connections appear to be largely random. Impulses are delivered through a large number of paths to the association areas of the cortex, where local feedback loops are activated, so that activity may persist for some time past the termination of the original visual stimulus. From the association area, signals are transmitted to the motor cortex, which again has a clear topological organization corresponding to the location of muscle groups to be controlled.

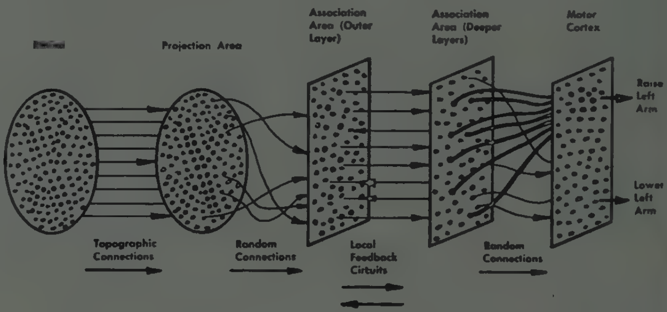

Fig. 1—Organization of a biological brain. (Heavy black areas indicate active cells, responding to the letter X.)

This general plan of organization has been considerably simplified in the perceptron. First of all, we will eliminate the projection area, and assume that the retinal points are directly coupled to association cells, or "A units." The number of input connections to each A unit is specified, but the locations of the origin points for the connections are selected at random from the set of sensory points. Each A unit receives some number, x, of excitatory connections, and some number, y, of inhibitory connections. The connection system from the sensory to association system is a many-to-many system. An excitatory connection from an illuminated sensory point is assumed to transmit a unit positive signal, while an inhibitory connection carries a unit negative signal. Each A unit has a fixed threshold, θ, and is triggered to deliver an output pulse if the algebraic sum (α) of the signals received from the $x+y$ input connections is equal to or greater than θ. A further simplification is introduced at the output side of the association system. Instead of delivering its output signals at random to a large number of "motor area" cells, the cells of the association system are connected to one or more binary response units, which are turned to their "1" state if they receive a positive signal from the association system, or to their "0" state if they receive a negative signal. The magnitude of the output signal generated by an active A unit is called the "value" of that unit, and is represented by the symbol v. The values of the units are stochastic variables, which change as a function of the history of the system. The organization of a simple perceptron with a single binary response is shown in Fig. 2. The total signal delivered by the set of A units is equal to $\Sigma\alpha_i^* v_i$ where α_i^* is equal to 1 if unit a_i is active, and 0 if a_i is inactive, and v_i is the current value of unit a_i. Note that there are two feedback lines from the response unit (or R unit) to the set of A units. These feedbacks control the "reinforcement," or changes in value, of the A units. In general, if the response $R=1$ occurs, active A units will gain in value, while if the response $R=0$ occurs, active units will lose in value. The value of the A unit thus acts as the memory variable for the system. It has been shown to be desirable to further modify the values of the A units by the rule that if some subset of units gains or loses in value, then the remainder of the units must change in the opposite direction just sufficiently to balance out the net change to zero. Thus, one unit can only gain parasitically, at the expense of the other units, and the total value of all of the A units is kept equal to zero at all times. A perceptron with this property is called a "gamma system." The theory of such systems has been considered in detail elsewhere [5], [6].

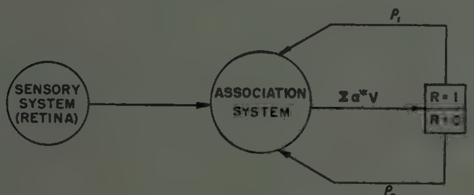
P_1
SENSORY SYSTEM (RETINA)
ASSOCIATION SYSTEM
$\Sigma\alpha^*V$
R=1
R=0
P_0

Fig. 2—Organization of a simple perceptron.

Description of Simulation Programs

Fig. 3 shows the organization of a typical simulation program, for the study of perceptron performance in an environment of visual forms. Actually, four basically different programs have so far been written with a number of variations of each, but the two programs which were used for most of the experiments reported here are both organized in the manner illustrated. The third program involves more direct methods of computation rather than true simulation, while the fourth program (designed to study "cross-coupled systems," in which A units may be connected to one another as well as to S points and R units) has proven too slow to be used successfully.[1]

The simulation programs have four main tasks, each of which is actually performed by a separate, self-sufficient program, which is stored on tape, and called into the computer by a supervisory routine. The supervisory routine reads instruction cards provided by the experimenter, which provide information on parameters, and control the sequence of subprograms performed in the course of the experiment. When each subprogram has been completed, control is passed back to the supervisory routine, which reads the next card for further instructions. In a typical experiment, the sequence is as follows:

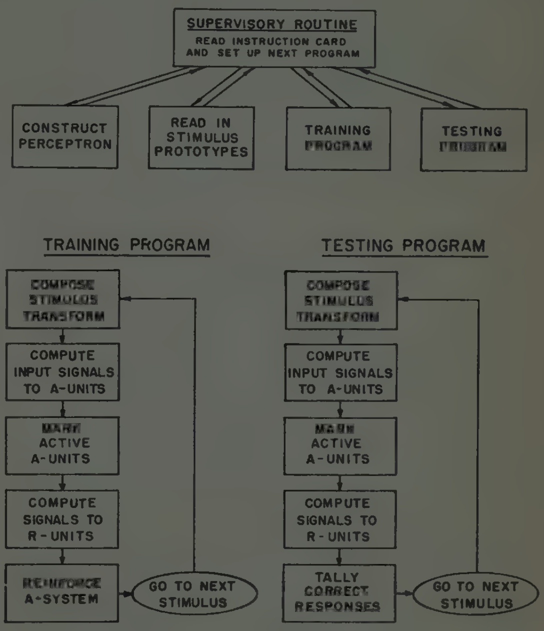
SUPERVISORY ROUTINE
READ INSTRUCTION CARD AND SET UP NEXT PROGRAM
CONSTRUCT PERCEPTRON
READ IN STIMULUS PROTOTYPES
TRAINING PROGRAM
TESTING PROGRAM
TRAINING PROGRAM
COMPOSE STIMULUS TRANSFORM
COMPUTE INPUT SIGNALS TO A-UNITS
MARK ACTIVE A-UNITS
COMPUTE SIGNALS TO R-UNITS
REINFORCE A-SYSTEM
GO TO NEXT STIMULUS
TESTING PROGRAM
COMPOSE STIMULUS TRANSFORM
COMPUTE INPUT SIGNALS TO A-UNITS
MARK ACTIVE A-UNITS
COMPUTE SIGNALS TO R-UNITS
TALLY CORRECT RESPONSES
GO TO NEXT STIMULUS

Fig. 3—Flow diagram for simulation program.

1) The perceptron construction routine is called into the core memory, and reads in a set of parameters describing the perceptron to be constructed. These parameters include the number of A units, the number of excitatory and inhibitory connections to each unit, the thresholds of the units, the number of R units, the number of R units connected to each A unit, the decay rate for A unit values (which decay with time in some models) and a random number to be used for priming the pseudo-random-number generator used to control the choice of connections. The program then selects for each A unit a set of $x+y$ sensory points to be assigned as origins for the input connections. This is done by generating a random number number modulo N_s (the number of sensory points) for each connection. This number is used to locate one of the N_s storage locations in which

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[1] The cross-coupled system was successfully simulated, and predicted effects obtained in December, 1959, using an improved program. Results will be reported in later publications.

the state of each sensory point is indicated when a "visual" pattern is presented.[2] The perceptron construction routine prepares a table listing all of these connections. In the first simulation program this table was stored on tape; but in the second program, by cutting down the admissible number of A units and connections, it was possible to store the entire table in the core memory, saving a factor of about five in running time of the program. The R units to which each A unit is connected are similarly assigned at random in each of the first two programs, which permit multiple output connections from each A unit. Since, in practice, all experiments have been concerned only with simple binary discrimination problems, more recent programs have been designed with only one R unit, to which all A units are connected. In the second program, it is also possible to assign an initial random distribution of values to the A units, although in most experiments it is assumed that the values start out uniformly from zero.

2) The second stage in the experiment calls for reading a set of "prototype stimulus patterns" into the memory of the computer. These patterns consist of actual dot images of the stimuli to be used, punched as patterns of holes in IBM cards. Thus, if it is planned to teach the perceptron the first four letters of the alphabet, we would read in the images of the letters A, B, C, and D, which are stored for future reference by later routines. These prototypes are never altered, but are used by the stimulus transformation routines which are included in the remaining two programs, to construct variously displaced, rotated, or contracted patterns which are the stimuli actually "shown" to the perceptron.

3) Having constructed the connection tables and read in the prototype stimuli, the computer is ready to begin the actual learning experiment. This consists of an alternation between the two remaining programs, one of which attempts to "teach" the perceptron to recognize the stimulus patterns, while the other evaluates the performance of the perceptron at intervals specified by the control cards. For example, in a typical experiment, the discrimination of the letters "E" and "X," the procedure is as follows. First, a control card calls for the training program to show ten different transformations of the letter "E" (the first stimulus). Each of these is generated by applying a vertical and lateral shift of random magnitudes between zero units of retinal distance and a maximum shift specified by the control card, a rotation between zero degrees and a specified maximum, and a size somewhere between a specified lower and upper bound. Random numbers generated by the routine determine the exact transformation to be applied to each stimulus, and a new image is composed. The control card then specifies that the response "1" is to be reinforced as the appropriate response for the letter "E." The program accordingly calculates the signals received by each A unit from the transformed stimulus, determines which A units are active, and reinforces the units according to the rules for reinforcement of the $R=1$ condition, for the gamma system, *i.e.*, each active A unit gains an increment in value, while the inactive units lose a compensating amount. In the second of the simulation programs, it is also possible for the stimulus to persist for a designated number of cycles, undergoing a random walk during this time, consisting of unit displacements, rotations, or size changes from the position in which it first appeared. This procedure is characteristic of the "forced learning mode" of experiment, which is the only mode possible for the first simulation program. In this mode, the desired response is turned on, or forced, by the training program at the same time that a stimulus is presented. The second program is also designed to permit a "spontaneous learning mode," in which stimuli occur in a random sequence, and the response spontaneously occurring upon presentation of the stimulus is reinforced, regardless of whether or not it is the response ultimately desired. Most of the experiments to be described in this paper were performed in the forced learning mode. After having presented the ten transformations of the letter "E" which were called for, and reinforced the response $R=1$ for each transformation, control is returned to the supervisory routine, which reads the next control card. In this typical experiment, we next call for ten transformations of the letter "X," to be associated to the response $R=0$. This procedure is carried out in the same manner as before.

We now switch to the testing program, which composes a series of stimulus transformations in the same manner as the training program, and goes through an identical set of calculations to determine the active A units in each case. Instead of reinforcing the association units, however, this program merely records the response, and checks it against the desired response for correctness. If the response is correct, it increments a tally of correct responses. Typically, we may look at twenty transformations of the "E" and twenty transformations of the "X," determining in each case the percentage of correct responses ($R=1$ or $R=0$, respectively). During this procedure, a running description of the responses of the system, numbers of active units, and other analytic data, are printed out by the computer. We may now present another ten E's and another ten X's, reinforcing the system as before, then test the performance once more, to find out whether this additional training has improved the performance, and thus continue alternating between training and testing programs indefinitely. It is also possible to reverse the assigned responses in the middle of the experiment, thus reversing previous learning. In order to obtain unambiguous comparisons of performance in different parts of the training series, the testing series are generally "primed" with the same random number to guarantee that the same stimulus transformations will be used on each repetition of the program. The training programs, on the other hand, continue to select stimuli at random, independently of what has gone before. A comparison of the organization of the training and testing programs is presented in the flow diagrams in Fig. 3.

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[2] In each of the first two simulation programs, multiple connections from the same A unit to the same S point are prohibited. In the second program, an inverse constraint was originally employed, fixing the number of connections originating from each sensory point, and assigning termini at random in the association system. This was later modified by the addition of a scheme to obtain, as nearly as possible, uniform numbers of inputs to each A unit as well as fixed numbers of outputs from the sensory units. These variations have not seriously affected the performance of the program, but it appears that somewhat better performance is obtained with the numbers of inputs to the A units is kept uniform.

The two main simulation programs total about 5000 words each. The first program was designed to handle up to 1000 A units, and a 72 by 72 sensory mosaic. It was found that this large sensory system presented stimuli with a fineness of grain considerably better than the limits of discrimination of a thousand-unit perceptron, and at the same time, required an excessive amount of time for stimulus transformations, since each illuminated point in the stimulus must be transformed individually into its image point. The second program reduced the retina to a 20 by 20 mosaic, and limited the number of A units to 500. For the first system, the computing time averaged about 15 seconds per stimulus cycle, while in the second system the time was cut to about 3 seconds per cycle. Subsequent improvements in programming techniques indicate that it should be possible to reduce the computing time still further—say to about one second per cycle—for perceptrons of the size allowed by the second program. At the same time, however, analytic developments have suggested a way of actually calculating the exact performance of a given perceptron of the type discussed above, provided all possible stimuli are known, and a matrix of g coefficients, describing the interactions of each pair of stimuli, is computed for the particular network in question. This technique is discussed in the appendix to [7], and is the method employed in the third of our simulation programs for the analysis of spontaneous learning in infinite perceptrons. In that program, the response of the system is obtained analytically, rather than simulated, but the sequence of stimuli is governed by a series of random numbers generated by the program. We will consider some of the results of this program later in this paper.

THEORETICAL PREDICTIONS AND PROBLEMS

Before considering the results of the simulation experiments, let us review the main predictions coming from the theory of the perceptron (see [5]–[7]). The simulation experiments were designed in part to verify these predictions, and in part to study problems which were suggested by the theoretical investigations.

Fig. 4 shows a set of theoretical performance curves for perceptrons of three different sizes, in the problem of discriminating a square from a circle. The broken curves (for P_r) show the probability of giving the correct response to a stimulus which is identical in position, size, etc., to one which was shown previously, during the training period. The horizontal axis indicates the number of stimuli of each class (squares and circles) which were presented during the training period. The solid curves indicate the probability of correct response to *any* square or circle, regardless of whether it was used as a training stimulus or not. Note that both sets of curves approach the same asymptotes as the number of training stimuli becomes large. The first task of the simulation program was to check the general character of these learning curves for typical stimulus material, such as letters of the alphabet or geometric patterns. In particular, it was essential to determine whether the rates of learning agreed with the predicted rates, at least to a reasonable approximation.

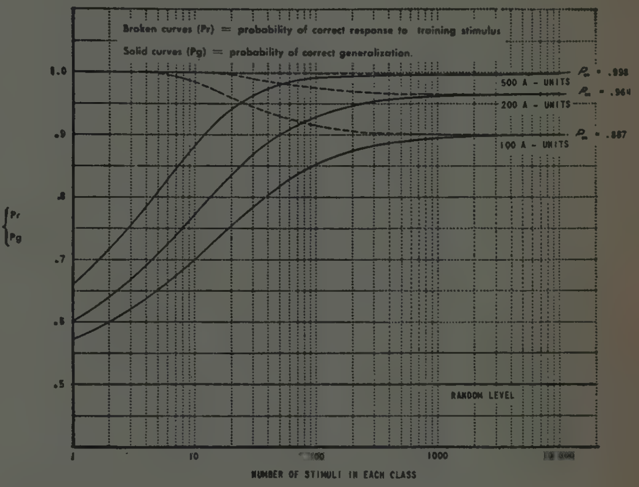

Fig. 4—Learning curves for three typical perceptrons.

A second problem concerned the effect of particular types of transformations, such as shifting of stimuli, rotations, or size changes, upon the learning curves. The original theory did not distinguish among these types of transformations, and it was important to find out whether the system would work equally well for all of them. While sufficient demonstrations have now been made of performance under shifting and rotation conditions, the problem of size changes remains a serious one, with a number of special cases. One such special case involves the assignment of different responses to two stimuli, one of which could be considered a "part" of the other, such as a small circle which could be completely imbedded in a larger one, or the letter "F," which can be considered as an "E" with the lower bar missing. It was predicted that such discriminations would be possible only with a mixture of excitatory and inhibitory input connections, excitatory connections alone being insufficient.[8]

Related to the problem of size variation in the stimuli is the problem of frequency variation, *i.e.*, some kinds of stimuli being more frequent than others. The response assigned to the more frequent stimulus type will generally tend to dominate the response assigned to the less frequent type, unless the system is designed in such a way as to minimize interaction between different classes of stimuli. The extent of this frequency bias was one of the problems originally set for the simulation programs, but a systematic investigation has not yet been completed.

A different problem area concerns the performance of linear systems. At one stage of the perceptron program, we were particularly interested in systems in which no threshold at all was employed in the A units, the output simply being equal to αv (the algebraic product of the input signal and the stored value) rather than $\alpha^* v$, as in the model described above. The values were to be augmented by a quantity equal to α if $R=1$, and diminished by α if $R=0$. It can easily be shown that in such a system, if a stimulus pattern can occur with equal probability anywhere in the retinal space (and eliminating special boundary conditions, as in the toroidally connected model), the expected value of every A unit after a long series of stimulus exposures will be exactly zero. Such a system clearly would not learn at all, if stimuli were distributed uniformly in space. If the stimuli were *not* uniformly distributed, however, the values would tend to correlate with any bias existing in the input signals, and it was predicted that such a system should learn to discriminate. The second simulation program was originally set up to study linear systems of this type, both in forced learning and spontaneous learning experiments. The theory of such systems in spontaneous learning is considered elsewhere [7]. While linear systems have now been abandoned, a typical experiment will be considered presently, as it illustrates several points of interest.

The problem of spontaneous learning—the ability of a perceptron to form meaningful classifications of stimulus patterns without any assignment of "correct" responses by a human experimenter—has prompted an extensive series of experiments. The effect was originally demonstrated with the second simulation program, where two disjunct classes of stimuli were properly separated, in a number of experiments. More interesting results were obtained with the third program, which eventually pointed the way to the development of the "cross-coupled association system," which promises to yield substantially improved performance in a large variety of problems [8]. In studying these spontaneous learning effects, the first question was whether they could actually be obtained at all, and the second was how much experience would be required, a question for which no satisfactory theoretical answer had been found at the time the simulation experiments were undertaken. In this area, there has been particularly close feedback between simulation work and development of the theory, the simulation program frequently demonstrating the existence of special cases, involving particular parameters or particular stimulus forms, which had not been anticipated. More recent theoretical models owe a great deal to this period of empirical exploration.

RESULTS OF SIMULATION EXPERIMENTS

The first experiments which we shall consider are concerned with the discrimination of the letters "E" and "X" in a forced learning situation, and are illustrated in Fig. 5. The stimuli were constrained to a central portion of the field (as shown by the insert) partly to facilitate learning, and partly to prevent truncation at the boundaries, since the toroidal stimulus space was not used in this program. Fig. 5(a) shows the probability of correct generalization (P_g) as measured on a sample of 20 X's and 20 E's. The stimulus sequence consisted of ten X's followed by ten E's, followed by a test of performance; then ten more X's, ten more E's, and a second test, for a total of 100 training stimuli. The data points shown in the figure are means obtained from ten 100 A unit perceptrons, each of them having a different connection network, but exposed to the same sequence of stimuli. The curves in Fig. 5(b) show the performance of a larger (1000 A unit) perceptron, on a more difficult variation of the same problem. In the solid curve, we see the performance of the system for stimuli rotated by some integral number of degrees selected at random between 0 and 30 degrees. This rotation is combined with vertical and horizontal translations selected within the same limits as in the preceding case. For rotations up to 30 degrees, note that the system attains perfect performance after only ten stimuli of each type. The broken curve shows the performance of the same system for rotations up to 359 degrees, combined with translations as above. In this case, there is a definite decline in the perceptron's performance, although it has attained a P_g of better than 0.90 after 30 stimuli of each type.

The next experiment (Fig. 6) was designed to check the hypothesis that performance on outline figures should be better than on solid figures, since unlike figures represented by their contours would have a minimum intersection on the retina, while solid areas might still have a large intersection even though their shape was different. The figures used were squares (illustrated in the inset) and diamonds, which covered the same areas as the squares, rotated 45 degrees. As shown by the two curves, the outline figures did indeed yield a better performance than the solid figures, giving a per-

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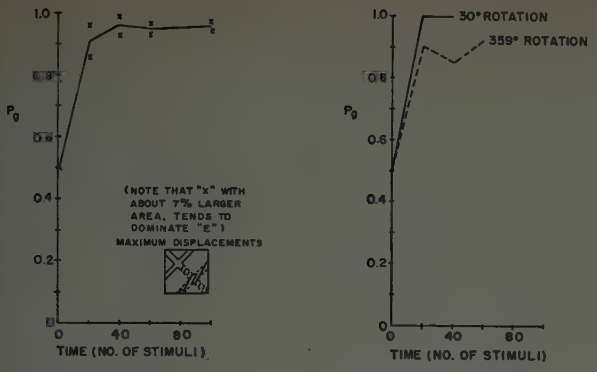
[8] F. Rosenblatt, "The Perceptron: A Theory of Statistical Separability in Cognitive Systems," Cornell Aero. Lab., Buffalo, N. Y., Rept. no. VG-1196-G-1; January, 1958. See p. 53.



(a) (b)

Fig. 5—(a) Experiment 10. "E" vs "X." No rotation. Centers placed in 13 by 13 field, in 72 by 72 retina. $N_A=100$, $\theta=2$, $x=5$, and $y=5$. (b) Experiments 20, 21. "E" vs "X" with shifting plus rotation. $N_A=1000$, $\theta=4$, $x=10$, and $y=0$.

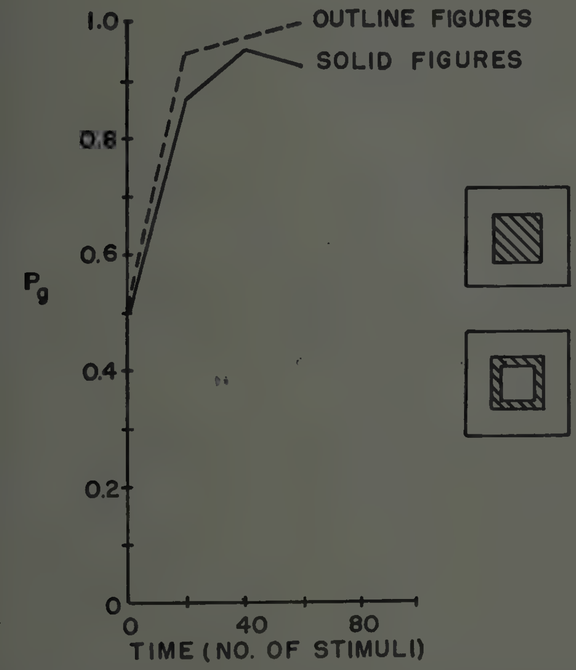
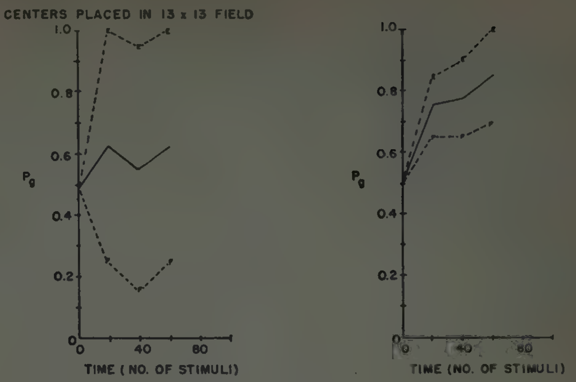


Fig. 6—Experiments 16, 17. Square-diamond discrimination. $N_A=1000$, $x=10$, $y=0$, and $\theta=4$. Centers placed in 13 by 13 field.

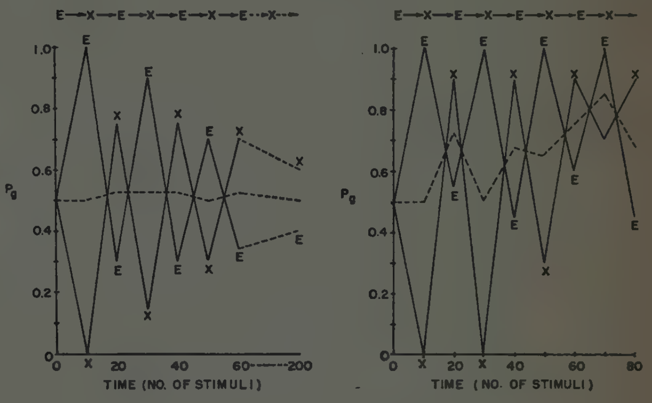
fect response record after 60 training stimuli (30 of each class). In this experiment, of course, rotation was eliminated to avoid confusion of squares and diamonds, and the figures were merely displaced in the same manner as the E's and X's in the preceding experiment.

Fig. 7 shows two experiments concerned with part-whole discrimination, which was discussed in the preceding section. In Experiment 18, illustrated in Fig. 7(a) a system with only excitatory connections to the A units was simulated. The stimulus is shifted at random in the central portion of the field, as before. In this case, the letter "E" was correctly learned, but the system was unable to learn to give the opposite response to the letter "F." In Experiment 22, shown in Fig. 7(b), we see that



(a) (b)

Fig. 7—(a) Experiment 18. "E" vs "F." $N_A=100$, $x=10$, $\theta=4$, and $y=0$. Centers placed in 13 by 13 field. (b) Experiment 22. "E" vs "F." $N_A=1000$, $x=5$, $\theta=3$, and $y=5$.



(a) (b)

Fig. 8—Linear system experiments ("E" vs "X"). (a) Experiment 4-14, 15. $N_A=500$, $x=4$, $y=4$. Centers placed in 13 by 13 field. (b) Experiment 4-16. $N_A=500$, $x=4$, and $y=4$. Centers placed in 5 by 5 field.

a system, in which half of the connections to the A units are inhibitory, is able to learn the correct response to both classes of stimuli, although the F response is considerably less consistent then the E response. Experiments 18 and 22 are, unfortunately, not fully comparable, as the perceptron in the second case was a thousand-unit system, while in Experiment 18 only a hundred A units were used. The character of the curves in these experiments, however, is definitely not a function of the size of the systems, but rather of the stimulus relationships, as shown by supporting evidence from many other cases. These results are in closer agreement with the theoretical predictions referred to earlier.

The next experiment (Fig. 8) was performed with the second simulation program, and represents the learning which is possible with a purely linear model, if the stimuli are constrained to one region of the retinal field. In this experiment, instead of testing the perceptron after every twenty stimuli, as in previous experiments, it was tested after every ten stimuli, which yields the characteristic pattern of converging oscillations shown in the figure. The first ten stimuli were all E's, and after these ten exposures, we find that the system has learned the "E" perfectly, but always gives the wrong response to stimuli of the opposite class (the letter "X"). The perceptron was then shown ten X's, to which the opposite response was forced, and we find at time 20 that it has now learned to give the desired response to the X, but has almost completely forgotten the proper response to the letter E. The amplitudes of such oscillations are apt to be increased by a large decay rate for the values of the A units (which makes more recent reinforcement more effective than earlier experience), but in the experiment illustrated here the decay rate was zero. Note that in Experiment 4-16 [illustrated Fig. 8(b)] the mean learning curve, shown by the broken line, climbs towards a high probability level as experience with both stimuli increases. At the same time, the swings in performance become considerably less pronounced, as each series of ten stimuli represents a progressively diminishing portion of the total experience of the system. The important conclusion from this experiment is that discrimination learning *is* possible for a linear system, provided the stimuli are sufficiently constrained in location. The retinal field in this case was 20 by 20 units, and the centers of the stimuli were constrained to a 5 by 5 region in the center of the retina. In Experiment 4-14 [shown in Fig. 8(a)], where the stimuli were distributed more freely over the retina (with the centers in a 13 by 13 field), no learning was demonstrated even after 200 stimuli. As a methodological experiment, these results indicate the importance of making sure that the stimulus distribution employed does not include "location cues" which are sufficient to indicate which stimulus is present, if we wish to test the ability of the perceptron to discriminate pattern characteristics exclusive of location. This can be fully guaranteed, in general, only by a uniform stimulus distribution over the entire field, with the elimination of special boundary effects by assuming a closed space, or an infinite space, as with the Born-von Kármán boundary conditions referred to in the Introduction.

Experiment 4-36, shown in Fig. 9, was again carried out with the second simulation program, this time with a more conventional perceptron. The threshold of zero, employed here, is sufficient to make the system fundamentally nonlinear, by eliminating the output of A units in the presence of negative input signals. The experiment was designed to show the performance of the system in the presence of a high degree of randomness, or noise, in the initial values of the A units. The stimuli for this experiment were vertical and horizontal bars, 4 units in width and 20 units long. A 5 per cent decay rate was introduced for the values of the A units. Note that in spite of the high decay rate and high initial noise level, the system achieved perfect performance on both classes of stimuli after a total of only 50 stimuli. This should be compared with the performance of very large (or infinite) perceptrons, in a spontaneous learning experiment with the same types of stimuli, which is illustrated in Fig. 10.

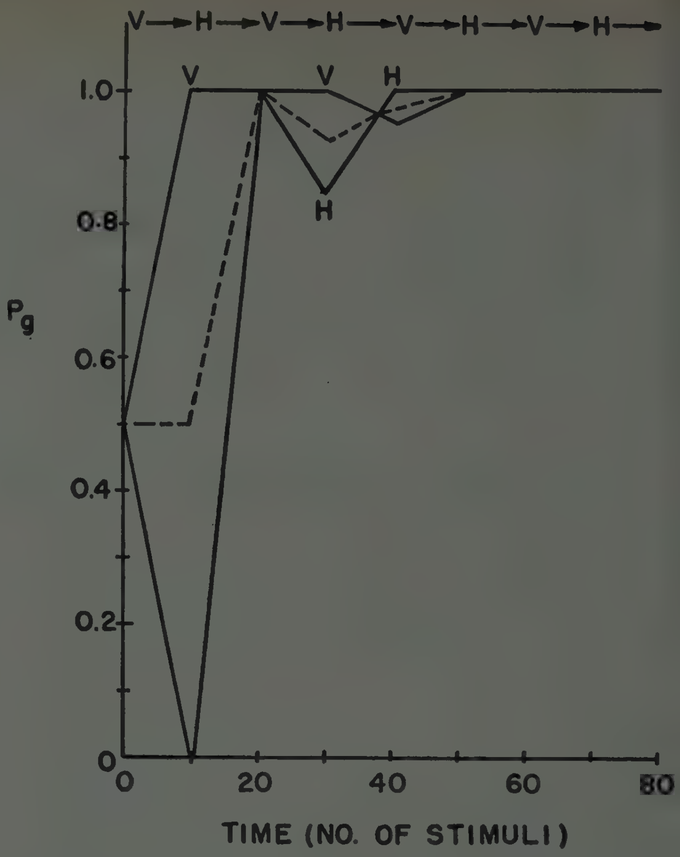
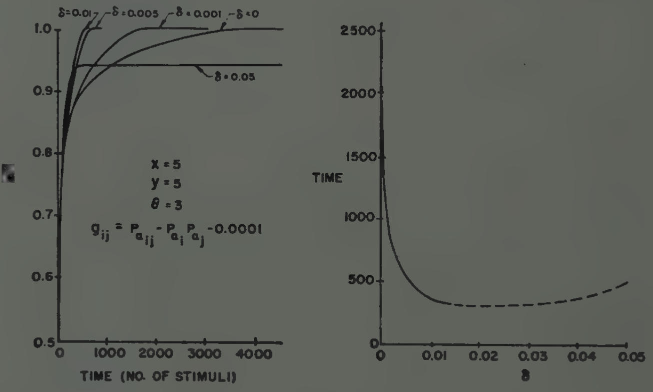


Fig. 9—Experiment 4-36. Forced learning experiment with vertical and horizontal bars. 500 A units. $\delta=0.05$, $\theta=0$, $x=4$, $y=4$, and V_0 = between +500 and −500. Centers in 5 by 5 field, in 20 by 20 retina.



(a) (b)

Fig. 10—Experiment 5-4. (a) Spontaneous organization of infinite perceptron in environment of 4 by 20 vertical and horizontal bars. (b) Expected waiting time to perfect performance, as a function of decay rate (means of 10 runs).

In the experiment shown in Fig. 10, stimuli were placed with equal probability at any position in a 20 by 20 retinal field, with Born-von Kármán boundary conditions. The stimuli were 4 by 20 horizontal and vertical bars, as in the previous case. The perceptron used in this experiment is one in which the A units are reinforced for the response R=1, but are left unaltered if the response R=0 occurs. Unlike all of the previously illustrated experiments, this is a spontaneous learning experiment, in which no attempt is made to control the response during the learning procedure, reinforcement being applied for whichever response is elicited by a given stimulus. The perceptron here was assumed to have an infinite number of A units, and the calculations were done with the third program, which was specifically designed to handle these conditions. The family of curves in Fig. 10(a) shows the performance as a function of the decay rate, δ. We find that for a zero decay rate, the system eventually learns to dichotomize the bars correctly 100 per cent of the time, *i.e.*, it learns to assign one response to all horizontal bars, and the opposite response to all vertical bars. However, this takes upwards of 3000 stimuli in most cases.[4] As the decay rate increases, performance improves progressively, until a decay rate is reached (0.05 in this case) for which the system is unstable, and never attains perfect performance. The effect of the decay short of the instability level appears to be to keep previous reinforcements from accumulating to such a degree that they are difficult or impossible to undo, as the system settles into a more satisfactory terminal state; in other words, the decay keeps the system flexible, by making it possible to reverse the effects of previous learning more readily. At the instability level, previous reinforcements are reversed so readily that they are unable to maintain their effect at all, and associations are likely to be lost and reformed continually. The curve in Fig. 10(b) which shows expected waiting time to perfect performance, for the same series of runs, indicates the same phenomenon. We find that there is a clear optimum in performance as a function of the decay rate, for $\delta =$ approximately 0.01. Beyond this point, instability begins to occur, as indicated by the broken curve in the figure.

This experiment is the best demonstration to date of the "self-organizing" capability of a perceptron. Nonetheless, it can be demonstrated that minor changes in the stimulus environment will make it impossible for the same perceptron to achieve a satisfactory dichotomy. For example, if the 4 by 20 horizontal bars are replaced by double bars, composed of two 2 by 20 vertical bars separated by a space of 3 units, the perceptron will never spontaneously learn to distinguish the double bars from the single bars. Other classes of stimuli can be set up which are equally difficult, or impossible, for the system to learn spontaneously, although in each of these cases the problem would present no difficulty in a forced learning situation. Moreover, the curves in Fig. 10 are convex, indicating increasing difficulty in correctly associating the last few stimuli after most of the class has been learned. In a human subject faced with this task we would expect concave curves instead. These considerations indicate that the spontaneous learning capability of this perceptron, while interesting, is not sufficient to provide a basis for a biological theory of perceptual organization. This problem is considered in further detail elsewhere [8].

CONCLUSIONS

The simulation experiments described above have gone a long way toward demonstrating the feasibility of a perceptron as a pattern-recognizing device. Both forced learning and spontaneous learning performances have been investigated, and some insight has been gained into conditions under which different systems break down, or deviate from typical biological learning phenomena. Although digital simulation is apt to be time-consuming and expensive, particularly for large networks, improved programming methods have cut down the running time considerably, so that for early investigations of all systems proposed up to this time, digital simulation is still competitive with the construction of actual hardware models. As the number of connections in the network increases, however, the burden on a conventional digital computer soon becomes excessive, and it is anticipated that some of the models now under consideration [8] may require actual construction before their capabilities can be fully explored.

Digital programs undertaken to date have been concerned exclusively with the logical properties of the network, rather than with any particular hardware embodiment; that is, there has been no attempt to introduce simulation of electronic noise, component variation, or other factors which might affect the performance of an actual system. The results of these programs, therefore, should be interpreted as indicating performances which might be expected from an "ideal," or perfectly functioning system, and not necessarily as representative of any particular engineering design. A Mark I perceptron, recently completed at the Cornell Aeronautical Laboratory, is expected to provide data on the performance of an actual physical system, which should be useful for comparative study.

A new program is currently being employed to simulate the "cross-coupled perceptron" described elsewhere [8]. The results of this study will be reported separately when they are available.

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[8] F. Rosenblatt, "Perceptual Generalization Over Transformation Groups," *Proc. of Interdisciplinary Conf. on Self-Organizing Systems;* 1959. Awaiting publication by Pergamon Press, New York, N. Y.

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[4] Individual runs differ from one another due to differences in stimulus sequence, even though the perceptrons are infinite; the curves shown are means of ten different runs.

Pulse Compression—Key to More Efficient Radar Transmission*

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Summary—**Increased demand for greater detection ranges in radar systems is often thwarted by the transmitting tube peak power limitation which, for narrow pulse operation, is usually reached before the full average power capability of the tube is realized. The technique of pulse compression offers a means of increasing the average power available to illuminate radar targets without any loss at the receiver of the resolution needed for the tactical requirements of the system. This is accomplished by transmitting a wide pulse in which the carrier is frequency modulated and then, by proper signal processing methods, causing a time compression of the received signal to a much narrower pulse of high effective peak power. The spectra and time functions of a particular class of pulse compression signals are analyzed and the basis for compression filter design is derived. Test waveforms demonstrate the resolving capability of the pulse compression technique.**

INTRODUCTION

SINCE THE inception of the military applications of radar techniques, emphasis has been placed on extending the ranges at which objects may be detected. In most instances, the demand for increased detection range has not been at the expense of normal tactical requirements for a certain minimum amount of range resolving capability. Faced with this situation, radar tube designers have been forced to concentrate on stepping up the peak powers of their tubes, since the tactical considerations have not permitted extending detection ranges by increasing average power by means of a wider transmitted pulse. As a consequence, in many situations high-powered tubes are being used inefficiently as far as average power is concerned. To compensate for this inefficiency, engineers have developed post-detection integration techniques to extend the radar detection range. These techniques also lead to further inefficiencies as far as the use of total available average power is taken into consideration. It will be the purpose of this paper to study a technique for increasing the average power capability of a pulse radar so that there is neither an increase in peak power nor a degradation of pulse resolution.

PULSE COMPRESSION EVOLUTION

Several individuals have been concerned with the problem outlined above and have sought means for solving the problem of increasing radar detection range when the pulse width must be kept fixed and peak power limitations control the average power that may be used.[1–3] R. H. Dicke and S. Darlington in the United States have proposed more or less identical approaches, but on the basis of patent applications Dicke would appear to have priority of conception as far as the ideas discussed here are involved.

Dicke reasoned that if the carrier frequency of a transmitted pulse were linearly swept, as shown in Fig. 1(b), a pulse compression filter with the time-delay vs frequency characteristic of Fig. 1(c) could be used to delay one end of the pulse relative to the other. This would produce, at the filter output, a narrower pulse [Fig. 1(d)] which would be of greater peak amplitude. The linear time-delay characteristic of the filter would act to delay the high-frequency components at the start of the input pulse more than the low-frequency components at the end of the pulse, with frequency components in between experiencing a proportional delay. The net result would be a time compression of the pulse. Since a passive linear filter is postulated, the principle of the conservation of energy applies and the buildup in peak power of the compressed pulse would be proportional to the ratio of the widths of the filter input and output pulses. Thus

$$\frac{\hat{P}_0}{\hat{P}_i} = \frac{T}{\tau} \qquad (1)$$

where

$\hat{P}_i$ = peak power input pulse,
$\hat{P}_0$ = peak power compressed pulse.

If the pulse width τ represents the desired resolution, it can be seen that if this technique is feasible a pulse of width T, representing an increase in average power, may be transmitted with an associated frequency modulation that contains the information necessary to construct the desired compressed pulse of greater effective peak power. However, the actual peak power limitations of a pulse radar system are by-passed, thus opening another avenue for extending radar performance.

HEURISTIC ANALYSIS OF LINEAR FM PULSE COMPRESSION

The basis for undertaking investigation of the type of system postulated by Dicke stemmed from the heuristic reasoning given below. The more rigorous analysis is

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* Original manuscript received by the IRE, July 7, 1958; revised manuscript received May 28, 1959 and November 23, 1959.

† Air Armament Division, Sperry Gyroscope Co., Great Neck, N. Y.

[1] R. H. Dicke, "Object Detection Systems," U. S. Patent No. 2,624,876; January 6, 1953.

[2] S. Darlington, "Pulse Transmission," U. S. Patent No. 2,678,997; May 18, 1954.

[3] W. Cauer, German Patent No. 892,772; December 19, 1950.

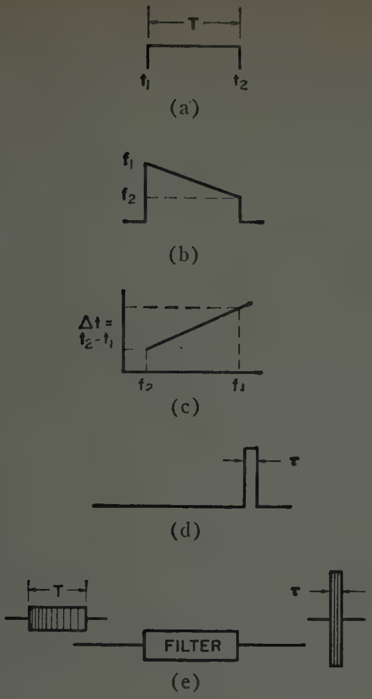


Fig. 1—Idealized pulse compression characteristics. (a) Wide-pulse envelope. (b) Carrier-frequency modulation. (c) Filter time-delay characteristic. (d) Compressed-pulse envelope. (e) Input-output wave forms of compression filter.

supplied in the next section and in the Appendix.

The transmitted pulse is to have a rectangular envelope and a carrier frequency that is of the form

$$\omega = \omega_c + \mu t \qquad |t| < \frac{T}{2}\cdot \tag{2}$$

The phase angle of the transmitted frequency becomes, when envelope contributions are ignored,

$$\phi = \int \omega dt = \omega_c t + \tfrac{1}{2}\mu t^2 + C_1. \tag{3}$$

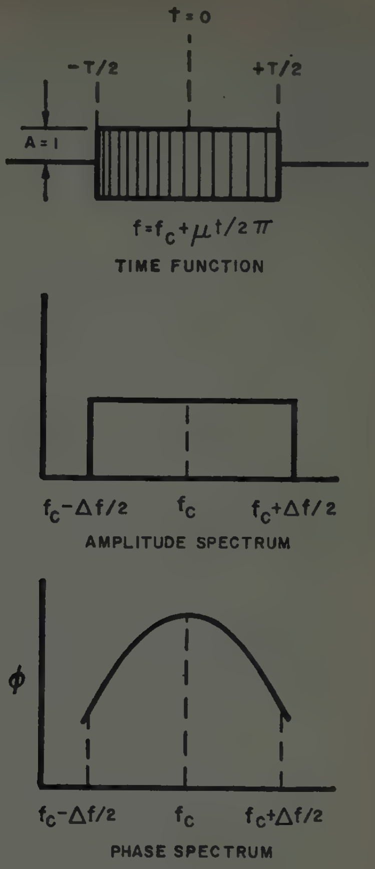
Thus, the phase angle ϕ is seen to contain a square-law term

$$\tfrac{1}{2}\mu t^2. \tag{4}$$

Further, if the product of the transmitted pulse width T and the frequency deviation $\Delta f = \Delta\omega/2 = f_2 - f_1$ is large, the linear progression of the carrier frequency between f_2 and f_1 should result in an essentially rectangular spectrum-amplitude distribution. Fig. 2 plots the essential features of the pulse derived by this method of reasoning.

The compression filter is to have a linear time-delay vs frequency characteristic of opposite sense to the linear frequency sweep. Functionally, this may be expressed as

$$t_d = 2K(\omega - \omega_1) + b. \tag{5}$$



TIME FUNCTION

AMPLITUDE SPECTRUM

PHASE SPECTRUM

Fig. 2—Wide-pulse waveform parameters and assumed amplitude and phase spectra.

Since the filter is being used in a band-pass application, the associated filter phase shift is

$$\beta_f = \int t_d d\omega = K(\omega - \omega_1)^2 + b\omega + C_2. \tag{6}$$

It must be realized that in a practical filter design only that portion of the phase function which corresponds to a positive time delay can be synthesized. The relationships of (5) and (6) are plotted in Fig. 3.

If the constants μ and k are properly matched, the spectrum at the compression-filter output is assumed to consist of a rectangular amplitude distribution and a flat or linear phase component. The time function of the compressed pulse is easily recognized from the spectrum parameters as having a $(\sin x)/x$ envelope, the pulse width being $\tau = 1/\Delta f$ when measured 4 db down from the peak amplitude. The spacing between the first zeros of this envelope is $2/\Delta f$. The carrier frequency under the above assumptions is a constant, f_c, and the peak amplitude is, of course, $\sqrt{T\Delta f}$ (Fig. 4).

No loss of generality will result if the compression filter is assumed to have a bandwidth Δf and a rectangular amplitude response centered at f_c. This reduces the operation to matched filtering in the North sense if the second-order effects are ignored in this type of analysis.

The results obtained above confirm the earlier assumption that such a pulse compression system would

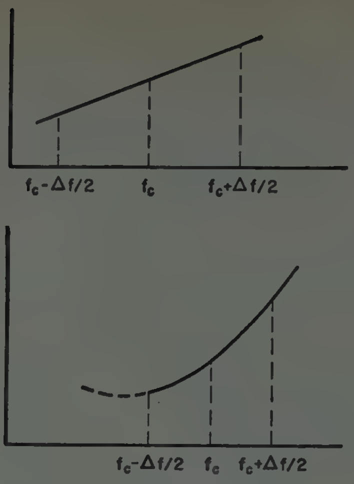


Fig. 3—Compression filter time-delay and phase shift.

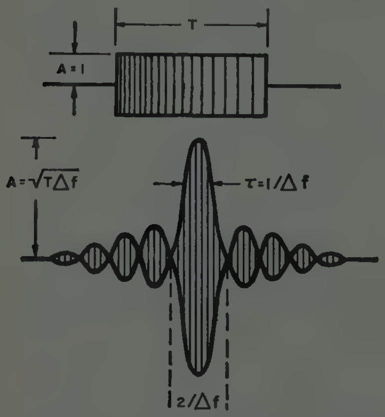


Fig. 4—Wide-pulse and compressed-pulse waveforms derived by heuristic analysis.

yield an output pulse of width $\tau=1/\Delta f$ (measured at the appropriate point) having an increased peak power ratio

$$\frac{\hat{P}_0}{\hat{P}_i}=\frac{T}{\tau}=T\Delta f.$$

The less obvious result was that the shape of the compressed pulse would be $(\sin x)/x$ and not rectangular. This may not be the most desirable pulse waveform for some radar applications because of the high sidelobe levels. Reducing these unwanted signals is entirely analogous to antenna-pattern sidelobe reduction, and some useful efforts in this area have been reported.[4,5]

DERIVATION OF LINEAR FM PULSE COMPRESSION SPECTRA

For the system under study, the transmitted signal function is

$$f(t)=A\cos\left(\omega_c t+\tfrac{1}{2}\mu t^2\right),\quad -\frac{T}{2}<t<\frac{T}{2},\tag{7}$$

where the carrier frequency is

$$\omega=\omega_c+\mu t.$$

If the constant A is neglected, the spectrum of this signal is

$$\begin{aligned}F(\omega)&=\int_{-T/2}^{T/2}\cos\left(\omega_c t+1/2\mu t^2\right)e^{-j\omega t}dt\\&=\frac{1}{2}\left[\int_{-T/2}^{T/2}\exp j\left[(\omega_c-\omega)t+\tfrac{1}{2}\mu t^2\right]dt\right.\\&\qquad\left.+\int_{-T/2}^{T/2}\exp -j\left[(\omega_c+\omega)t+\tfrac{1}{2}\mu t^2\right]dt\right].\end{aligned}\tag{8}$$

The second integral essentially defines the spectrum at negative frequencies and has a negligible contribution at positive frequencies, provided the ratio $f_c/\Delta f$ is sufficiently large, which would be the case in any practical application of pulse compression.

The spectrum expression, after a suitable change of variables, becomes

$$F(\omega)=\frac{1}{2}\sqrt{\frac{\pi}{\mu}}\,e^{-j(\omega_c-\omega)^2/2\mu}\int_{\sqrt{\pi/\mu}\,(-T/2+(\omega_c-\omega)/\mu)}^{\sqrt{\pi/\mu}\,(T/2+(\omega_c-\omega)/\mu)}e^{j(\pi/2)x^2}dx.\tag{9}$$

The above integral yields

$$\begin{aligned}F(\omega)&=\frac{1}{2}\sqrt{\frac{\pi}{\mu}}\,e^{-j(\omega_c-\omega)^2/2\mu}\\&\cdot\left[C\left(\frac{\frac{\mu T}{2}+(\omega_c-\omega)}{\sqrt{\pi\mu}}\right)+jS\left(\frac{\frac{\mu T}{2}+(\omega_c-\omega)}{\sqrt{\pi\mu}}\right)\right.\\&\left.+C\left(\frac{\frac{\mu T}{2}-(\omega_c-\omega)}{\sqrt{\pi\mu}}\right)+jS\left(\frac{\frac{\mu T}{2}-(\omega_c-\omega)}{\sqrt{\pi\mu}}\right)\right]\end{aligned}\tag{10}$$

where

$$C(x)=\int_0^x\cos\frac{\pi}{2}y^2dy\tag{11a}$$

and

$$S(x)=\int_0^x\sin\frac{\pi}{2}y^2dy\tag{11b}$$

are the Fresnel integrals.

Expressing the spectrum function in the form

$$F(\omega)=e^{-\alpha s-i\beta s},$$

then the spectrum amplitude-function is

$$e^{-\alpha s}=\frac{1}{2}\left(\frac{\pi}{\mu}\right)^{1/2}\left\{\left[C(x_1)+C(x_2)\right]^2+\left[S(x_1)+S(x_2)\right]^2\right\}^{1/2}\tag{12a}$$

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[4] T. T. Taylor, "Design of Line Sources for Narrow Beamwidth and Low Side Lobes," Hughes Aircraft Co., Culver City, Calif., Tech. Memo No. 316; July, 1953.

[5] C. E. Cook, "Modification of Pulse Compression Waveforms," presented at Natl. Electronics Conf., Chicago, Ill.; October 15, 1958.

and the spectrum phase-function is

$$\beta_s = (\omega_c - \omega)^2/2\mu - \tan^{-1}\left[\frac{S(x_1) + S(x_2)}{C(x_1) + C(x_2)}\right] \qquad (12b)$$

where

$$x_1 = \frac{\dfrac{\mu T}{2} + (\omega_c - \omega)}{\sqrt{\pi\mu}} \quad \text{and} \quad x_2 = \frac{\dfrac{\mu T}{2} - (\omega_c - \omega)}{\sqrt{\pi\mu}}.$$

If, as implied in the previous section, matched filtering is attempted, the filter transfer characteristics $e^{-\alpha_f - i\beta_f}$ must be conjugate to the spectrum function derived above, that is

$$e^{-\alpha_S} = e^{-\alpha}.$$

and

$$\beta_S = -\beta_f.$$

In practice, the phase characteristic of the compression filter is made to match only the imaginary square-law spectrum component, assuming that the residual phase term

$$-\tan^{-1}\left[\frac{S(x_1) + S(x_2)}{C(x_1) + C(x_2)}\right]$$

will not prove harmful. The consequences of this assumption are shown in the results of the Appendix.

The Fresnel functions do not represent a closed-form solution, and the spectrum functions must be derived from tables of Fresnel integrals.[6,7] The Fresnel function argument is

$$y = \left[\frac{\dfrac{\mu T}{2} \pm (\omega_c - \omega)}{\sqrt{\pi\mu}}\right]. \qquad (13)$$

By making the substitutions

$\mu = \Delta\omega/T$, $\Delta\omega$ = frequency deviation within wide pulse,
$\Delta\omega = 2\pi/\tau$, τ = narrow pulse width,
$\omega_c - \omega = n\Delta\omega/2$,

then

$$y = \sqrt{\frac{T}{\tau}}\left(\frac{1 \pm n}{\sqrt{2}}\right). \qquad (14)$$

The argument, y, appears as a function of the compression ratio T/τ, and is seen to be independent of the absolute amount of the frequency deviation, $\Delta\omega$.

Fig. 5 illustrates the shape of the spectrum components for various values of compression ratio. As this ratio increases, the amplitude distribution becomes more nearly rectangular and the residual phase component flat over the band of frequencies of major interest. The derivation of pulse shapes for these spectra made use of numerical summation. In each instance, the combination of the real and imaginary spectrum components produced a wave-form arbitrarily close to the $(\sin x)/x$ function and of the prescribed peak amplitude. As this study program developed, a closed-form solution for this method of pulse compression (linear frequency sweep within a rectangular pulse and a square-law phase compression filter) was obtained by J. E. Chin of the Sperry Gyroscope Co., and is given in the Appendix. This analysis showed that the filter-output pulse envelope is precisely of the $(\sin x)/x$ form. Moreover, it was shown that the carrier of the filter output pulse is frequency swept at the same rate as the input pulse but in the opposite direction. However, the total frequency deviation between the first zeros of the compressed pulse is given by

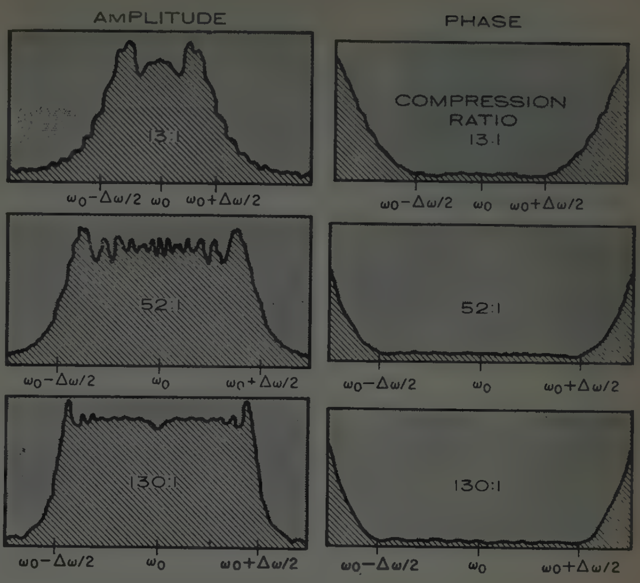

Fig. 5—Postcompression amplitude and phase spectra for various compression ratios.

$$2\frac{\Delta\omega\tau}{T}. \qquad (15)$$

Whether this represents a serious problem or not will depend on the particular application and the compression ratio involved. Physically, the presence of this residual frequency modulation may be explained as arising from the frequency components introduced by the rise and fall portions of the wide-pulse envelope. These frequency components do not occur at the times dictated by the linear sweep of the carrier frequency. The resultant effect of the compression filter is to disperse these components in a manner to produce the reverse frequency sweep cited above. (This explanation results from the additional analysis of linear FM pulse-com-

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[6] E. Jahnke, and F. Emde, "Table of Functions," Dover Publications, Inc., New York, N. Y.; 1945.

[7] A. Van Wijngaarden and W. L. Scheen, "Tables of Fresnel Integrals," Computation Dept. of the Mathematical Center, Amsterdam, The Netherlands, Rept. No. R49; 1949.

pression performed by B. L. Hulland of the Sperry Gyroscope Co.)

The foregoing analysis showed that the compression filter would require a square-law phase characteristic of the form

$$\beta_f = -(\omega_c - \omega)^2/2\mu;$$

the associated time delay is then

$$t_d = \frac{d\beta_f}{d\omega} = (\omega_c - \omega)/\mu.$$

This characteristic is physically unrealizable since it yields negative time delays over half the frequency band. This objection is met by adding a sufficiently large constant delay so that the filter time-delay is positive at all frequencies of interest. The modified filter time-delay is then

$$t_d' = (\omega_c - \omega)/\mu + k$$

and the phase characteristic to be approximated by the filter design is

$$\beta_f' = -(\omega_c - \omega)^2/2\mu + k\omega + C_2.$$

The type of network chosen for the filter design was the bridged-T equivalent (see Fig. 6) of the all-pass constant-resistance lattice network. Design techniques for all-pass networks are well covered in the literature,[8–10] and the minute design details of a particular application need not be examined here. As the name implies, all-pass networks theoretically have no losses. Network purists will insist, and rightly so, that this characteristic cannot be obtained in practice, especially at frequencies in the IF range. However, judicious use of phase and amplitude compensating networks will provide the necessary engineering approximation for a system application.

Fig. 7 indicates a possible laboratory arrangement to test the pulse compression characteristics of a particular filter design. Increased compression ratios may be obtained by cascading additional sections of the designed filter. Figs. 8 and 9 indicate the type of test results that may be expected. Fig. 8 shows a representative compressed pulse, this being an IF waveform in which the lower half has been masked out to reveal the signal sidelobe detail more clearly. Fig. 9 shows the uncompressed pulses from two inputs and their respective video detected outputs from the compression filter for several degrees of overlap of the input signals. This demonstrates the linear operation of this technique in that the output response for broad overlapping pulses from multiple inputs will be precisely the superposition of the responses from each input when the others are absent. The amplitude ripples on the wide pulses illustrate the effect of the compression-filter delay line on the frequency-swept input signals.

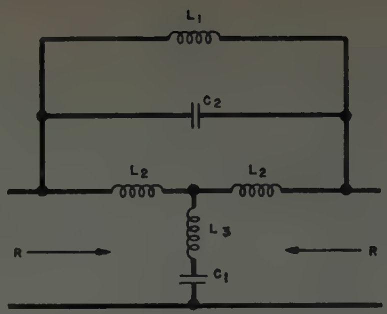

Fig. 6—General form of bridged-T all-pass network.

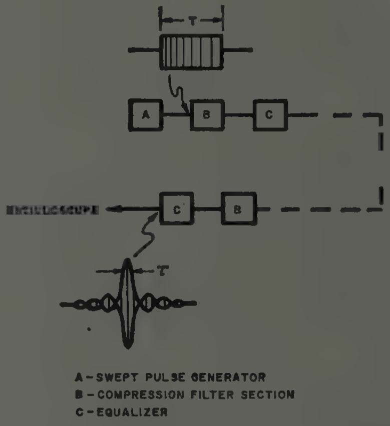

Fig. 7—Compression-filter laboratory test equipment.

CONCLUSION

A technique for increasing the average power capability in peak power limited pulse-transmission systems has been analyzed. The theoretical aspects are closely allied to matched-filter and cross-correlation methods. The derived pulse shape for this technique is $(\sin x)/x$, but the waveform may be modified by approaches that are analogous to the reduction of antenna-pattern sidelobes.

APPENDIX

The following closed-form solution of linear FM rectangular-envelope pulse compression is the result of the contributions of J. E. Chin to this study program.[11]

$$f(t) = \exp\left[j(\omega_c t + \tfrac{1}{2}\mu t^2)\right] \qquad -T_0 \leq t \leq T_0$$
$$f(t) = 0 \qquad |t| > T_0. \tag{16}$$

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[8] O. J. Zobel, "Distortion correction in electrical networks with constant resistance recurrent networks," *Bell Sys. Tech. J.*, vol. 7, pp. 438–534; July, 1928.

[9] E. A. Guillemin, "Communications Networks," John Wiley and Sons, Inc., New York, N. Y., vol. 2; 1935.

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[11] J. E. Chin and C. E. Cook, "The mathematics of pulse compression—a problem in systems analysis," *Sperry Engrg. Rev.*, vol. 12, pp. 11–16; October, 1959.

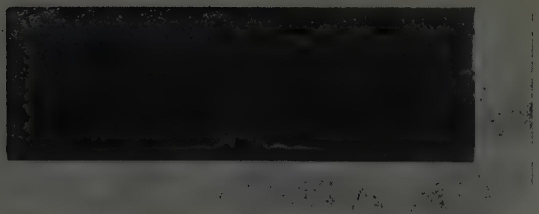

Fig. 8—Compression-filter IF waveform (lower half of waveform masked to reveal greater sidelobe detail).

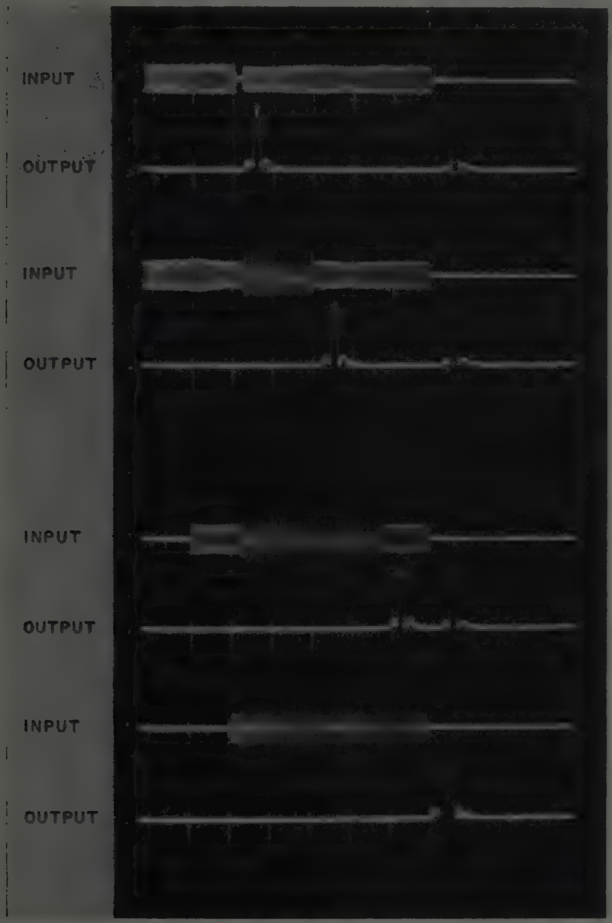

Fig. 9—Multiple inputs and detected outputs of a pulse compression filter illustrating principle of superposition.

The pulse spectrum is

$$F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}\,dt$$

$$= \int_{-T_0}^{T_0} \exp\left\{j\left[(\omega_c - \omega)t + \tfrac{1}{2}\mu t^2\right]\right\}dt. \quad (17)$$

The generalized compression-filter function is

$$H(\omega) = \exp\left[j\,\frac{(\omega_c - \omega)^2}{2\mu}\right] \quad (18)$$

and the filter-output spectrum $G(\omega) = F(\omega)H(\omega)$

$$\therefore G(\omega) \doteq \exp\left[j\,\frac{(\omega_c - \omega)^2}{2\mu}\right]$$

$$\int_{-T_0}^{T_0} \cdot \exp\left[j(\omega_c - \omega)t + \tfrac{1}{2}\mu t^2\right]dt. \quad (19)$$

The term $g(t)$ represents the output time function where

$$g(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} G(\omega)e^{j\omega t}d\omega. \quad (20)$$

Thus,

$$g(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty}\left(\exp\left[j\,\frac{(\omega_c - \omega)^2}{2\mu}\right]\right.$$

$$\left.\int_{-T_0}^{T_0} \cdot \exp\left[j(\omega_c - \omega)\tau + j\,\frac{\mu}{2}\,\tau^2\right]d\tau\right)e^{j\omega t}d\omega. \quad (21)$$

This rearranges to

$$g(t) = \frac{1}{2\pi}\int_{-T_0}^{T_0}\left[\exp j\left\{\tfrac{1}{2}\mu\tau^2 + \omega_c\tau + \frac{\omega_c^2}{2\mu}\right.\right.$$

$$\left.\left. - (\omega_c + \mu\tau - \mu t)^2/2\mu\right\}\right]$$

$$\cdot\left[\int_{-\infty}^{\infty} \exp\left[j(\tfrac{1}{2}\mu)\{\omega - (\omega_c + \mu\tau - \mu\tau)\}^2\right]d\omega\right]d\tau \quad (22)$$

letting

$$u = \frac{\omega - (\omega_c + \mu\tau - \mu t)}{\sqrt{2\mu}}$$

$$g(t) = \frac{\sqrt{2\mu}}{2\pi}\int_{-T_0}^{T_0}\left[\exp j\left\{\frac{\mu\tau^2}{2} + \omega_c\tau + \frac{\omega_c^2}{2\mu}\right.\right.$$

$$\left.\left. - (\omega_c + \mu\tau - \mu t)^2/2\mu\right\}\right]\left[\int_{-\infty}^{\infty}\exp(ju^2)du\right]d\tau, \quad (23)$$

but

$$\int_{-\infty}^{\infty} e^{ju^2}du = \int_{-\infty}^{\infty}(\cos u^2 + j\sin u^2)du = \sqrt{\pi}e^{j\pi/4}$$

and

$$g(t) = \sqrt{\frac{\mu}{2\pi}}\; e^{j(\omega_c t - 1/2\mu t^2 + \pi/4)}\int_{-T_0}^{T_0} e^{j\mu t\tau}\,d\tau$$

$$= \sqrt{\frac{2\mu}{\pi}}\exp\left[j\left(\omega_c t - \frac{1}{2}\mu t^2 + \frac{\pi}{4}\right)\right]\int_0^{T_0}\cos\mu t\tau\,d\tau$$

$$= \sqrt{\frac{2\mu T_0^2}{\pi}}\;\frac{\sin\mu t T_0}{\mu t T_0}$$

$$\cdot\exp\left[j\left(\omega_c t - \frac{1}{2}\mu t^2 + \frac{\pi}{4}\right)\right]. \quad (24)$$

Now

$$\mu = \frac{2\pi\Delta f}{2T_0}$$

where Δf = swept-frequency deviation. The output-input peak power ratio is derived by squaring the amplitude of the output pulse, the input amplitude having been taken as unity. This yields

$$\frac{2\mu T_0^2}{\pi} = \left(\frac{4\pi\Delta f}{2T_0}\right)\left(\frac{T_0^2}{\pi}\right) = 2T_0\Delta f. \qquad (25)$$

If the wide pulse width assumes the same dimensions as in the section on spectra derivation

$$2T_0 = T,$$

then the output-input pulse width and peak-power ratios become $T\Delta f$, if the convention is adopted that the output pulse is measured at the points $t = \pm\frac{1}{2}\Delta f$.

ACKNOWLEDGMENT

The investigation reported herein is part of the general program of the Sperry Gyroscope Co., for studying advanced techniques. W. W. Mieher and C. E. Brockner were chiefly responsible for the guidance and support necessary to provide program continuity. The author is also indebted to J. E. Chin, L. R. Sadler, and J. Cerar, who have made substantial contributions to the progress of the project.

CORRECTION

In a correction to the paper, "The Parametron, a Digital Computing Element which Utilizes Parametric Oscillation," by E. Goto, which appeared on page 1840 of the November, 1959 issue of PROCEEDINGS, R. G. Allen and J. E. Mezei have advised the editors of two typographical errors in the explanatory equations. For clarity, the entire correction is repeated here.

The five input parity-check circuit (Goto's Fig. 13) which should give a "1" output when an odd number of inputs are "1" does not appear to be correct, possibly because of an error in drafting.

Fig. 13 represents the following logical function:

$$f(x, y, z, u, v) = [[x\,\bar{y}\,z\,\bar{u}\,v][\bar{x}\,y\,\bar{z}\,u\,v][x\,\bar{y}\,z\,\bar{u}\,v][\bar{x}\,y\,\bar{z}\,u\,v][\bar{v}]]$$

where the square brackets represent the majority function.

This five majority function can be reduced to the simpler function:

$$f(x, y, z, u, v) = [[x\,\bar{y}\,z\,\bar{u}\,v][\bar{x}\,y\,\bar{z}\,u\,v][\bar{v}]]$$

which does not yield the desired result in four cases (Table I) of the thirty-two possible combinations of five binary variables. A correct logical function for a five input parity check is

$$f(x, y, z, u, v) = [[x\,\bar{y}\,z\,\bar{u}\,v][\bar{x}\,y\,\bar{z}\,u\,v][\bar{x}\,y\,z\,\bar{u}\,v][x\,\bar{y}\,\bar{z}\,u\,v][\bar{v}]]$$

which would be represented by the logical circuit shown in Fig. 1.

TABLE I

x	y	z	u	v	Goto Circuit Result	Desired Result
1	0	1	0	0	1	0
0	1	0	1	0	1	0
1	0	1	0	1	0	1
0	1	0	1	1	0	1

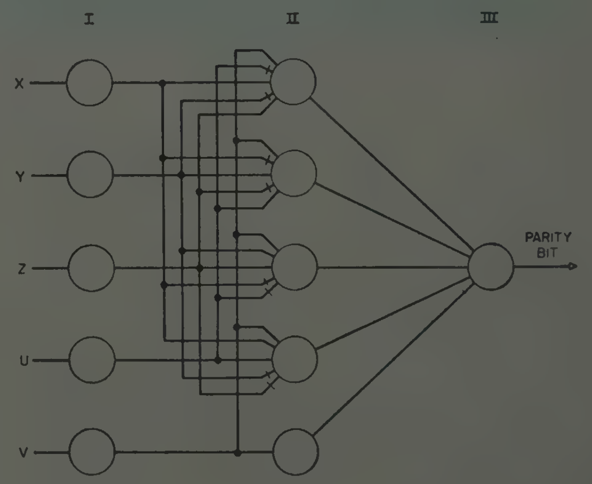

Fig. 1.

Field Effect on Silicon Transistors*

B. SCHWARTZ†, MEMBER, IRE, AND M. LEVY‡

Summary—**A field effect has been observed on an operating silicon transistor. The results have been interpreted as being due to changes in surface recombination velocity produced by changes in surface potential. Using this approach, it was possible to calculate the surface recombination velocity of the base region of an operating device directly, without having to go to a filament measuring technique and then extrapolating back to the device. Relaxation phenomena have also been observed which can be interpreted as being due to a transfer of charge between the fast and the slow states at the surface. Time constants for this transition have been calculated.**

INTRODUCTION

THE technique of capacitively applying an electrostatic field to alter the surface properties of semiconductor materials is one that has been used a great deal in the study of surface phenomena. Most of the work reported in the literature concerns itself with measurements made on germanium filaments of a single conductivity type;[1–9] some measurements on germanium *p-n* junctions have also been reported.[10,11]

With respect to field-effect measurements on silicon, the literature is quite meager. Penman and Brown,[12] Low,[13] and Dousmanis,[14] have reported on successful experiments using silicon as the base material. In general, though, the problem of obtaining an interpretable field effect on silicon has been rather formidable, and most experimenters have confined their work to the more responsive germanium.

EXPERIMENTAL TECHNIQUE AND RESULTS

This paper sets forth information obtained when dc electrostatic fields were applied normal to the surfaces of operating silicon *p-n-p* evaporative-fused-junction transistors. The primary parameter studied was α and the way it changed during the application of the field. For this study, apparatus was constructed in which a transistor could be placed in close proximity to a metallic field electrode. Fig. 1 is a schematic of the assembly pointing out the essential details. This method of assembly allowed us to achieve fields of up to 10^6 volts/cm before arcing ensued between the field electrode and the transistor. The resultant induced surface charge density produced by the maximum field was about 1.7×10^{12} charges/cm^2.

The capacitances in this assembly were small and did not appear to affect the field-effect measurements in any way. The capacitance of the field plate to the sample assembly was 9 $\mu\mu$f.

The transistor was operated in the common base configuration with a 1-milliampere emitter current and a 5-volt collector bias. The small signal α was read manually and it usually took the operator from 5 to 20 seconds to read the α once the field voltage had been applied.[15]

A typical example of the effects observed in the experiments on α is illustrated in Fig. 2. The α of the transistor is plotted as a function of time. When a positive voltage was applied to the field plate [see Fig. 2(a)], α dropped initially and, while the voltage was still on, returned approximately to its original value as time passed. When the voltage was turned off, α jumped to a new value, higher than the original one, and then decayed to its original value. Fig. 2 also shows the increase in α when a negative voltage was applied, and the subsequent decay in time. It can be seen from these results that turning off a positive voltage is analogous to turning on a negative voltage. The decay characteristics were reproducible to better than ±15 per cent.

The observed decay in α can be correlated with the transfer of charge between the fast and slow states at the surface of the base region of the transistor.

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* Original manuscript received by the IRE, June 22, 1959; revised manuscript received, September 21, 1959.

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[15] Since these measurements were made, the equipment has been modified. A recording system which has a response time of 1 second is now in use.

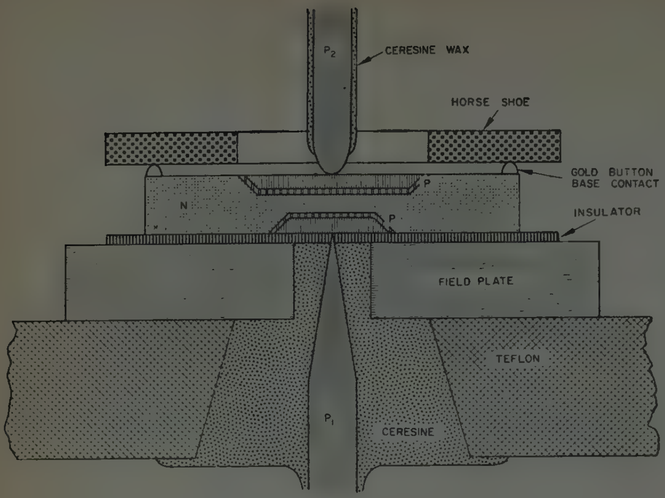

Fig. 1—Schematic of assembly used in experiments

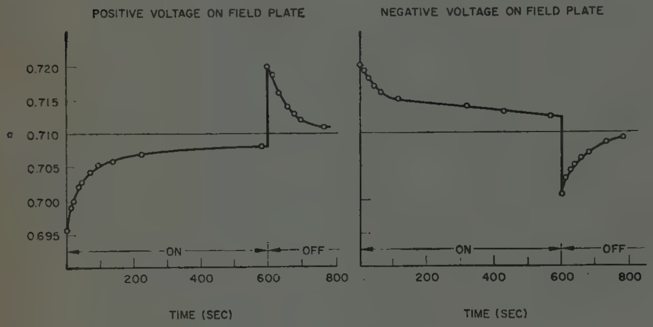

Fig. 2—α vs time while voltage is turned on and off.

Fig. 3 shows what happened to the initial alpha change ($\Delta\alpha_i$) of three transistors when voltages of different magnitude were applied to the field electrode.[16] The initial alpha change of the first transistor was directly proportional to applied positive or negative voltage. This was a low alpha transistor. The initial alpha change of the second transistor was directly proportional to applied positive voltage. However, when negative voltages were applied to the field plate, $\Delta\alpha_i$ appeared to saturate at about -1200 volts. The initial alpha of this transistor was high. $\Delta\alpha_i$ of the third transistor was proportional to applied negative voltage, but when a positive voltage was applied there was no measurable change in alpha.

Fig. 4 is a plot of log $|\Delta\alpha|$ vs time for transistor E-2 operating in the normal direction. A bias of +2600 volts was applied to the field plate which faced the emitter surface. The following equation was obtained from the experimental data:

$$|\Delta\alpha| = .0068e^{-t/60} + .0082e^{-t/340} \tag{1}$$

and two time constants were required to fit the experimental data.

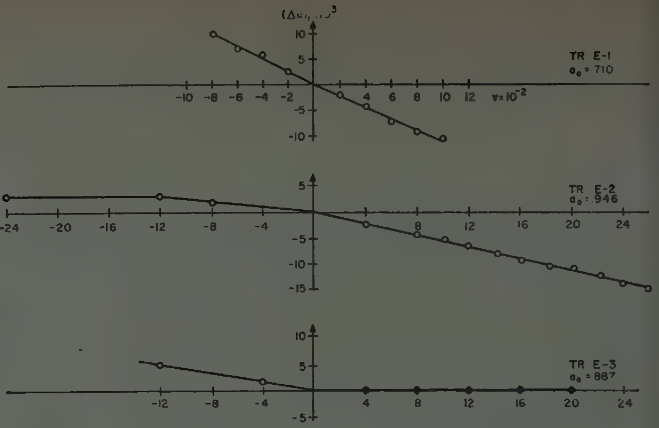

Fig. 3—Initial $\Delta\alpha$ vs field-plate voltage for three transistors.

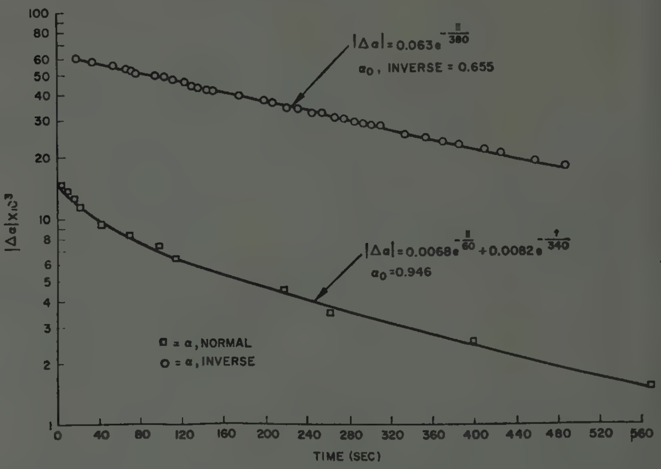

Fig. 4—Absolute value of $\Delta\alpha$ vs time for both normal and inverse α of transistor E-2 while a positive voltage was applied to the field plate.

Fig. 4 also shows a plot of log $|\Delta\alpha|$ vs time for the same transistor operating in the inverse direction. Again a positive voltage was applied to the field plate. The field plate faced the same surface as in the preceding experiment; *i.e.*, in both experiments the field plate faced the small area junction surface. In the first case the small area junction was used as the emitter, and in the second case the small area junction was used as the collector. The following equation was obtained for the latter case from the experimental data:

$$|\Delta\alpha| = 0.063e^{-t/380}. \tag{2}$$

Only one time constant was required to fit the experimental data and, within experimental error, this time constant is approximately the same as the longer time constant of (1). The presence of two time constants in (1) and only one in (2) is a rather confusing point and no completely acceptable argument has yet been developed to explain it.

A similar series of experiments was performed on a transistor where the field plate faced the large area junction. No noticeable effect was observed on normal α. Inverse α was affected only slightly by both positive and negative fields. These results led to the conclusion that if the transistor is operated in the normal direction, the size of the collector is large enough so that essentially no minority carriers are lost at the surface surrounding the collector.

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[16] Initial alpha change is defined as the maximum observable change in α when a voltage is applied to the field plate. Transistors E-1 and E-2 were measured in room air at 24°C and transistor E-3 was measured in vacuum (10^{-4} mm Hg) at 25°C.

INTERPRETATION OF RESULTS

The authors believe that the data of Fig. 3 may be used to determine qualitatively the surface potential of the transistors used. Webster's equation[17] indicates that α is essentially inversely proportional to surface recombination velocity, s. When a field is applied normal to the surface of a transistor the surface potential is changed, and in turn surface recombination velocity is affected. Many, *et al.*,[18] have shown a relationship between s and ϕ_s which is plotted in Fig. 5 for a trapping state energy of 0.48 ev, as found by Statz, *et al.*,[19] and a capture probability ratio of 5×10^8, which was reported by Buck and McKim for silicon.[20]

One can qualitatively place the surface potential of the three transistors of Fig. 3 at the positions shown in Fig. 5. This is done by observing in Fig. 3, for example, that for transistor E-2 the $\Delta\alpha_i$ saturates at about -1200 volts. When transistor E-2 is placed at the position shown in Fig. 5, it is seen that s "saturates" at its lowest value when ϕ_s is made more negative, and does not saturate when ϕ_s is made more positive. These factors are in good agreement, since a negative voltage on the field plate induces the surface potential to become more negative.

The placement of the three transistors in Fig. 5 merely from the data of Fig. 3 results in positive surface potentials for transistors E-1 and E-3. This raises what appears to be a disturbing contradiction, since the results of microlight-probe measurements on devices of the same type as those used here have always shown, under the same conditions of fabrication, treatment, aging, and measurement under standard atmospheric conditions, a conversion of type at the surface. The apparent contradiction can be overcome by consideration of two factors. First, if the capture cross section ratio were reduced by about one order of magnitude, then the placement of transistor E-1 could be such as to result in a conversion of type at the surface. At the same time, this would cause transistor E-2 to shift in surface potential into a region which agrees qualitatively with values obtained in some preliminary measurements of surface potential now being performed.[21]

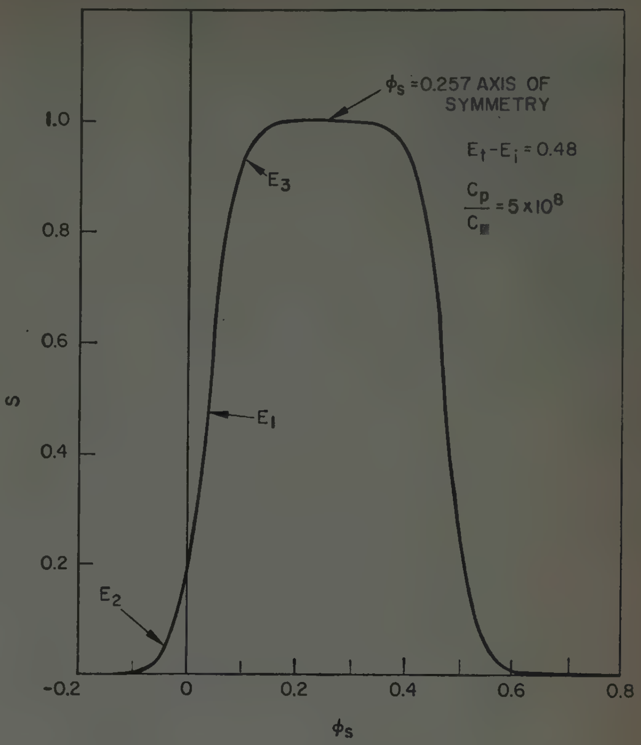

Fig. 5—Normalized surface recombination velocity vs surface potential (in electron volts).

The second factor is the effect of a vacuum on ϕ_s. Since transistor E-3 was measured not under atmospheric conditions but rather at a vacuum of 10^{-4} mm of Hg, special consideration must be given this case. When this unit was measured under atmospheric conditions the properties of this transistor looked very similar to those of transistor E-1; that is, there did not appear to be any saturation of $\Delta\alpha_i$ as the field electrode voltage was made positive or negative. When the unit was placed in a vacuum, the α_0 decreased noticeably and the emitter diode reverse current also decreased. These effects could have been produced by an increase in ϕ_s,[22] which would allow for the surface to reach a value of ϕ_s where conversion of type at the surface did not necessarily occur. The lowering of the capture cross section ratio would also be helpful here in that the maximum for s could be achieved closer to $\phi_s = 0$.

Another bit of information that agrees qualitatively with the "order" of placement of the three units in Fig. 5 is that the emitter diode reverse currents, as measured at 5 volts bias, were 8, 1300, and 5400 mμa for transistors E-3, E-1, and E-2, respectively. By considering the influence of channels on diode reverse current,[23] one could arrive at the conclusion that the surface potentials of these three units should be in the order ϕ_s(E-3) $\geq \phi_s$(E-1) $\geq \phi_s$(E-2).

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[21] Experiments to date indicate that the surface potential of a surface analogous to those used here is about -0.15 volt. This value is based on a very limited amount of information, but does seem to fit the argument qualitatively.

[22] Independent experimental measurements by the authors show that a vacuum does produce an increase in ϕ_s.

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The authors believe that in certain cases the information provided by the data in Fig. 3 may permit the computation of surface recombination velocity. This was done for transistor E-2 as follows.

If one assumes that s is made negligibly small when a negative voltage is applied to the field plate facing the emitter of transistor E-2, the surface recombination velocity term in the Webster equation may be neglected for that transistor, and an estimate may be made of the value of bulk lifetime, since the constants left in the equation may be obtained from independent measurements. Using the computed value of τ_b, s may then be estimated for transistor E-2 when no voltage is applied to the field plate (see Appendix). The surface recombination velocity was found to be 500 cm/sec and a displacement of 1.7×10^{12} charges/cm² increased s by 2000 cm/sec for this particular transistor. The computed value of s for transistor E-2 was rather small for silicon, but E-2 did have a relatively high α, which would imply a low surface recombination velocity.

CONCLUSION

The surface potential of an operating silicon transistor may be estimated by means of the field effect measurement if a strong enough field can be achieved. If this field strength can be reached, the surface recombination velocity may also be computed.

The time constants obtained for the $\Delta\alpha$ decay are dependent upon the age of the surface of the device and may give valuable information about the oxide layer covering the silicon surface, as well as about the mechanism of loss of carriers at the surface.

The field effect may also be used for determining optimum geometry configurations in an operating transistor.

APPENDIX

The following is Webster's equation which relates the power gain of a transistor to surface recombination velocity s, bulk lifetime τ_b, and emitter current I_e.

$$\frac{1}{\alpha} - 1 = \frac{sA_sW_b}{2AD_p} + \frac{W_b^2}{2D_p\tau_b} + \frac{W_b^2\mu_e}{2A\sigma_eL_eD_p} I_e, \qquad (3)$$

where α is the small signal ac emitter-to-collector current amplification factor, W_b the effective junction spacing, A_s the area over which surface recombination takes place, A the entire area of the emitter, D_p the diffusion constant for holes in the base region, L_e the diffusion length for electrons in the emitter region, μ_e the electron mobility, and σ_e the conductivity of the emitter region adjacent to the junction.

For the transistors used in these experiments

$$W_b \cong 2.54 \times 10^{-3} \text{ cm},$$

$$\mu_e = 48 \frac{\text{cm}^2}{\text{sec volt}},$$

$$I_e = 1 \times 10^{-3} \text{ amperes},$$

$$A = 1.26 \times 10^{-2} \text{ cm}^2,$$

$$\sigma_e = 56 \text{ ohm}^{-1} \text{ cm}^{-1},$$

$$L_e = 2 \times 10^{-3} \text{ cm},$$

$$D_p = 12 \frac{\text{cm}^2}{\text{seconds}}.$$

Putting in these values for the last term of (3), one gets

$$\frac{1}{2} \frac{W_b^2\mu_eI_e}{A\sigma_eL_eD_p} = 8.3 \times 10^{-6}. \qquad (4)$$

This term is negligible in comparison to the sum of the two other terms in (3), since even for a unit with an α of 0.95, $1/\alpha - 1 = 5.3 \times 10^{-2}$.

After the I_e term is neglected, the Webster equation simplifies to

$$\frac{1}{\alpha} - 1 = \frac{W_b^2}{2D_p}\left(\frac{2s}{r} + \frac{1}{\tau_b}\right) \qquad (5)$$

if the assumption is made that $A_s = 2\pi rW_b$, where r is the radius of the emitter junction.

For transistor E-2

$\alpha_0 = 0.946 =$ initial α,

$\alpha_1 = 0.949 =$ maximum α obtained while applying a negative V to the field plate,

$\alpha_2 = 0.932 = \alpha$ when +2500 volts are applied to the field plate,

$W_b = 2.42 \times 10^{-3}$ cm,

$r = 63.5 \times 10^{-3}$ cm,

$D_p = 12$ cm²/sec.

Assuming s is negligible when α is equal to α_1, then

$$\tau_b = \frac{W_b^2}{2D_p\left(\frac{1}{\alpha_1} - 1\right)} = 4.5 \times 10^{-6} \text{ sec}. \qquad (6)$$

When no voltage is applied to the field plate, $\alpha = \alpha_0$ and

$$s_0 = \left[\frac{\frac{1}{\alpha_0} - 1}{\frac{W_b^2}{2D_p}} - \frac{1}{\tau_b}\right]\frac{r}{2} = 460 \simeq 500 \text{ cm/sec}. \qquad (7)$$

When +2500 volts are applied to the field plate, $\alpha = \alpha_2$ and $s_2 = 2500$ cm/sec. Therefore a displacement of 1.7×10^{12} electrons/cm² increases s by 2000 cm/sec for this particular transistor.

ACKNOWLEDGMENT

The authors wish to thank M. Cutler, H. Bath, and R. Solomon for their many helpful comments and suggestions.

A Half-Watt CW Traveling-Wave Amplifier for the 5–6 Millimeter Band*

H. L. McDOWELL†, MEMBER, IRE, W. E. DANIELSON‡, AND E. D. REED‡, MEMBER, IRE

Summary—**The traveling-wave tube here described represents the first practical CW power amplifier with broadband performance in the millimeter wave band. More than 30 db of gain has been achieved over a bandwidth of 10,000 mc centered at 55,000 mc. A maximum CW output power of ½ watt has been obtained in this band. This combination of high power output and broadband performance represents a significant advance in the millimeter art.**

The electrical and mechanical techniques are described which were found successful in solving the problems peculiar to the high operating frequency. These problems are focusing, heat dissipation, intrinsic RF loss and structural precision. Experimental data on an operating tube are presented which show good agreement with predicted performance. These data suggest that the techniques described may be extended to allow either an increase in power to several watts at the present operating frequency or an increase in operating frequency to 150 kmc for output powers of a hundred milliwatts.

INTRODUCTION

FOR SOME years now the possibility of broadband communications at millimeter waves has been studied at Bell Telephone Laboratories.[1] This study has centered around the use of circular waveguide as a low-loss transmission medium. Transmission over a 40-kmc wide band, from 35–75 kmc, appears feasible in a single waveguide, but initial interest has been focused on the 50 to 60 kmc region. This interest in millimeter wave communications has stimulated vacuum-tube work both on primary signal sources[2–5] and on amplifiers. In this paper we shall describe an experimental helix-type traveling-wave amplifier with a CW power output of ½ watt in the 50 to 60 kmc band. This exceeds output powers previously obtained from CW amplifiers in this frequency range by at least an order of magnitude.

Results on early work on millimeter wave amplifiers were reported by Little[6] in 1951. In his tube a tiny unsupported helix was stretched between two posts and flooded by an electron beam. Cooling was entirely by radiation and output power thereby limited to a few microwatts. The net gain of this tube was about 3 db at 6 mm. Also in 1951, Millman[7] reported 20 db of low-level gain and an output power of about 20 mw at 7 mm from a tube having an all-metallic filter-type circuit. This tube had a bandwidth of about 7 per cent. In later millimeter wave work, the helix-type tube was revived by Robertson[8] in an attempt to obtain wider bandwidth. He supported the helix by four knife edges of quartz, but again cooling was mainly by radiation. He obtained a pulse power output of 5–10 mw at a 5 per cent duty cycle. The net gain was 10–15 db at 6 mm.

At the start of this program we thought that heat dissipation associated with the relatively high power output would force us to use an all-metallic filter-type structure such as Millman's, with a consequent loss in bandwidth. However, further studies showed that adequate power output could be obtained with a helix, if it was cooled by conduction and interception was kept very low. These studies led to the helix-type tube described below.

DESIGN CONSIDERATIONS

The major problems encountered in the development of this amplifier were direct consequences of the very small helix diameter necessitated by the high operating frequency. These problems were:

1) the need for adequate cooling of the helix;
2) the production of an electron beam of very small diameter and the focusing of this beam through the helix without requiring excessive cathode current density or excessive magnetic field;
3) the minimization of intrinsic helix attenuation; and
4) the precise alignment of gun, helix and magnetic field.

Our solutions to these problems will be treated separately in the following sections.

Direct scaling of typical lower-frequency TWT's would have resulted in a prohibitively small helix diameter of about 5 mils. To enable us to use a larger diameter, we chose to operate at the high ka value of 0.25. As a result we were able to use a 15-mill diameter—a value which seemed attainable through the techniques

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* Original manuscript received by the IRE, October 1, 1959.

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[7] S. Millman, "Spacial harmonic traveling-wave amplifier for six millimeters wavelength," PROC. IRE, vol. 39, pp. 1035–1043; September, 1951.

[8] S. D. Robertson, "Broadband helix traveling-wave tube for millimeter wavelengths," IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-2, pp. 48–54; September, 1954.

to be described. At the time, a *ka* of 0.25 seemed about as high as we could safely go without incurring backward wave oscillations. Subsequently we found that our method of supporting the helix introduced a strong stop-band around $ka=0.5$.[9] This means that we could probably increase *ka* to 0.4 in a future redesign without incurring backward wave oscillations. To make the frequency response of this tube as flat as possible, we chose γa equal to 1.5. This, together with the choice of *ka*, led to a comparatively high beam voltage and a large helix-length-to-diameter ratio. The relevant tube parameters are as follows.

$$\left.\begin{aligned} ka &= .25 \\ \gamma a &= 1.5 \end{aligned}\right\} \text{at 55 kmc}$$

Helix inside diameter = 15 mils
Helix pitch = 110 turns per inch
Helix length = 4 inches
Synchronous Voltage = 7000 volts
Beam current = 3 ma
Gain parameter $C=0.015$

The values of helix length and beam current were calculated assuming an output of 100 mw, an efficiency of one times C and a low-level gain of 25 db. Some of these parameters are discussed in more detail later.

Heat Transfer From the Helix

The helix is heated both by RF dissipation and intercepted beam current. This heat must be removed while maintaining the helix temperature low enough to prevent an undue increase in RF attenuation and a consequent loss of efficiency. This we have done by providing a direct thermal conduction path from the helix wire to the outside of the vacuum envelope. As shown in Fig. 1, the helix is glazed to a single wedge of dielectric which is forced against a massive copper heat sink by strong spring pressure. Dielectric rods of either Bell Laboratories F-66 steatite or of synthetic sapphire have been used. Beryllium oxide appears to be a still better material because of its very high thermal conductivity and it will be tried in the future. In finely divided form, however, it is highly toxic, and, its experimental evaluation will have to await the development of special grinding and processing techniques. These three dielectric materials—steatite, sapphire, and beryllium oxide—have thermal conductivities in the approximate ratio 1:10:100.

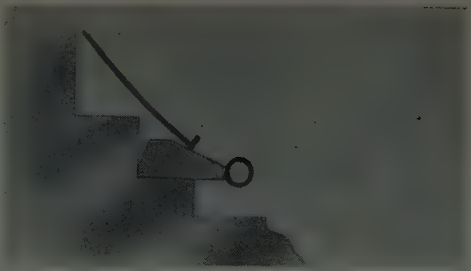

Fig. 1—Cross section of helix mounted on heat sink.

There are three sources of thermal impedance in the structure of Fig. 1. These are the glazed joint between helix and dielectric rod, the rod itself, and the interface between rod and heat sink. The first of these is rather small because the glaze, in wetting both the helix and the rod, provides an intimate thermal contact between them. The other two impedances may, however, be appreciable. We obtain a measure of their relative magnitudes by comparing the power dissipation properties of helices with steatite and sapphire rods. This was done by passing dc current through some sample helices mounted on a heat sink in a vacuum bell jar. The helix temperature was calculated from the rise in wire resistance and plotted against the dc power dissipated. Fig. 2 shows the results. The curves for helices mounted on a heat sink are approximately straight lines indicating that conduction is the main mechanism of heat transfer and that the thermal impedances are roughly constant. Whereas the intrinsic thermal conductivities of steatite and sapphire differ by a ratio of ten, the curves show that the apparent conductivities for the two materials differ by a factor of only 3: 200°C/watt/inch-of-helix-length for steatite vs 65°C/watt/inch for sapphire. This means that the thermal impedance of the interface between dielectric rod and heat sink is not negligible. Assuming it to be the same for the two materials, as a first-order approximation, we calculate its value to be 50°C/watt/inch. The impedance of the dielectric rod is then 150°C/watt/inch for steatite and is 15°C/watt/inch for sapphire. This shows that for the case of sapphire the interface impedance will largely control the temperature rise of the helix. A rough calculation of the termal impedance of the steatite rod from its geometry shows good agreement with the above results.

For comparison, Fig. 2 also shows the temperature rise for a helix glazed to a ceramic rod but suspended without contact to the heat sink so that it can only be cooled by radiation. As may be seen, the power that can be radiated from the helix for a given temperature rise is very much smaller than that which can be carried away by conduction.

Most of the helix heating is caused by beam bombardment—RF heating occurring in any appreciable magnitude only along the last few turns near the output. The beam interception in experimental tubes has ranged from 5 to 7 per cent. Assuming that this interception is distributed over one quarter of the helix length, we find that the temperature rise is 300°C for a steatite rod helix and 100°C for sapphire. Both of these values are within permissible limits.

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[9] This means of introducing a stop band is similar in principle to an earlier arrangement used by Poulter in which a helix was mounted in a quartz tube having a groove which intercepted the helix once each turn. See W. L. Rorden, "A 100 Watt CW TWT at S Band," Electronics Research Lab., Stanford University, Tech. Rept. 351-1; March 9, 1956.

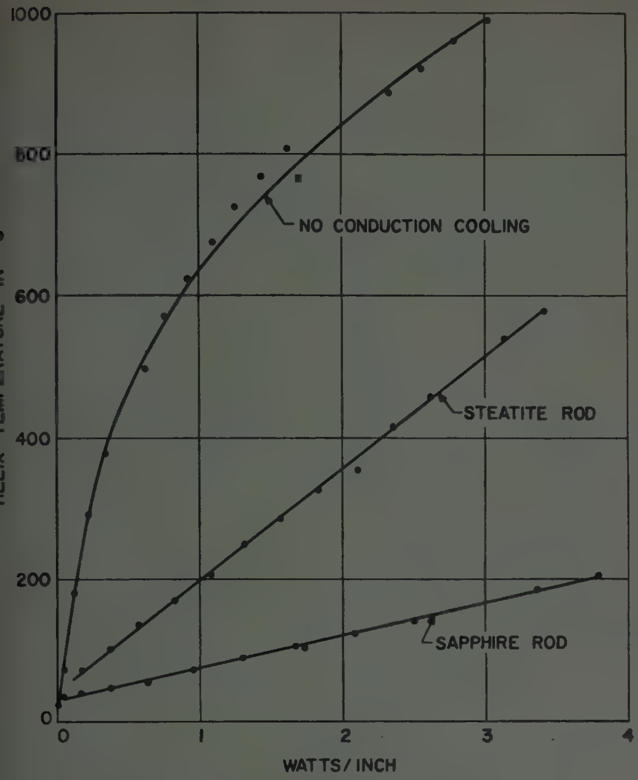

Fig. 2—Helix temperature vs power dissipated (per inch) in helix structure.

At the very output end, the helix will also be heated by RF power dissipation. This heating causes an increase in helix attenuation as a result both of increased wire resistivity and increased dielectric loss. The increased attenuation, in turn, lowers the power output thereby giving rise to fading; *i.e.*, if the beam is turned on suddenly, the power output will go to a maximum value and then decrease gradually over a period of about one minute while the helix heats up. The fading problem is aggravated by the necessity of stopping the heat sink short of the last few turns of the helix to make room for the helix-to-waveguide transducer. This makes the heat flow path from the end turns to the heat sink longer than from the remainder of the turns and thus increases the fraction of the total thermal impedance which is due to the dielectric rod. Thus, to minimize fading, it is especially important to obtain a high thermal conductivity dielectric rod. Fading has limited the power output of tubes with steatite rods to about one-half watt CW. The use of sapphire with about ten times the thermal conductivity will reduce fading considerably. Beryllium oxide which offers an additional factor of ten in thermal conductivity would probably produce little further improvement in fading in the present tube. However, if means were found to reduce the thermal impedance between dielectric rod and heat sink, this material should make possible a considerable increase in beam power. Coupled with an increase in *ka* to 0.4, this could conceivably result in a CW output of several watts.

BEAM FOCUSING

The problem of focusing the tiny electron beam differs from that commonly encountered in that the transverse thermal velocities with which electrons are emitted from the cathode become the predominant factor in determining the magnetic field required for adequate focusing.

To achieve a high-voltage convergent beam of much smaller diameter than had been produced in any of our previous work on convergent TWT beams, the gun design effort was accompanied by theoretical beam studies of quite general application. Herrmann,[10] who carried out both the analytical and the experimental phases of the initial gun work, extended calculations of thermal velocity effects in electron beams beyond the magnetically shielded gun region[11] to include the full region of magnetic focusing between accelerating anode and collector. Two particularly significant conclusions drawn from Herrmann's study are as follows:

1) Where thermal velocities play a dominant role, minimum magnetic field is obtained by shielding the cathode from the field.
2) Given the desired beam parameters (voltage, current and radius) and the cathode current density, the minimum magnetic focusing field can be predicted without any knowledge of the specific gun geometry used. Comparison of the actual focusing field required with this theoretical minimum thus affords a measure of excellence of the entire focusing system.

The expression for the minimum field is made up of three terms as follows:

$$B^2 = \underbrace{B_b^2}_{\text{Space Charge}} + \underbrace{B_t^2}_{\text{Thermal Velocities}} + \underbrace{B_k^2\left(\frac{A_k}{A_b}\right)^2}_{\text{Cathode Flux}}$$

where

B = minimum total magnetic flux density required,
B_b = Brillouin field to counteract space charge forces,
B_t = field required to counteract spreading due to thermal velocities,
B_k = magnetic flux density at the cathode,
A_k = cathode area, and
A_b = area of the beam.

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[10] G. F. Herrmann, "Optical theory of thermal velocity effects in cylindrical electron beams," *J. Appl. Phys.*, vol. 29, pp. 127–136; February, 1958.

[11] The basic approach to calculations in the accelerating region of a shielded Pierce gun had been developed by C. C. Cutler and M. E. Hines, "Thermal velocity effects in electron guns," PROC. IRE, vol. 43, pp. 307–315; March, 1955. More detailed calculations applicable to shielded guns having a larger range of thermal velocities had been given by W. E. Danielson, J. L. Rosenfeld, and J. A. Saloom, "Detailed analysis of beam formation with electron guns of the Pierce type," *Bell Sys. Tech. J.*, vol. 35, pp. 375–420, March, 1956; also by G. F. Herrmann, "Transverse scaling of electron beams," *J. Appl. Phys.*, vol. 28, pp. 474–478, April, 1957.

It is the space charge term which plays a dominant role in the much discussed case of Brillouin focusing. However, as the diameter of a beam is made smaller and smaller, the motion associated with transverse emission velocities remains essentially constant while the transverse motion due to space charge decreases with decreasing beam radius. In our tiny beams it is therefore not surprising that the magnetic field term due to thermal velocities is about 2½ times as large as that due to space charge. The actual dimensions of the millimeter tube gun are shown in Fig. 3. The gun is completely shielded from the magnetic field, making the third term in the magnetic field expression zero.

For a given beam diameter and current, the thermal velocity term B_t^2 is proportional to cathode area. Consequently, to minimize the required field, the cathode current density was made as high as possible, consistent with the probability of long cathode life.

A relatively long gun with a small angle of convergence was used to keep lens effects small. The measured beam convergence on scaled-up models of this gun has been about 20 per cent greater than calculated. To reduce the convergence and optimize focusing in the actual gun, a positive bias of 5 volts is applied to the beam-forming electrode. The accelerating anode voltage must therefore be reduced from its design value in order to maintain the desired beam current. This necessitates post acceleration between the anode and the helix, thus giving rise to an additional lens effect. The magnetic field is introduced rather suddenly by an aperture in a magnetic pole piece brought inside the vacuum envelope. No attempt has been made as yet to optimize the geometry of this region. Experimentally, about 95 per cent beam transmission from cathode to collector has been obtained with 1500 gauss magnetic field. This compares favorably with a calculated minimum field of 1200 gauss. With some effort at eliminating the post-acceleration and optimizing the entrance conditions of beam into the magnetic field, it should be possible to increase the transmission.

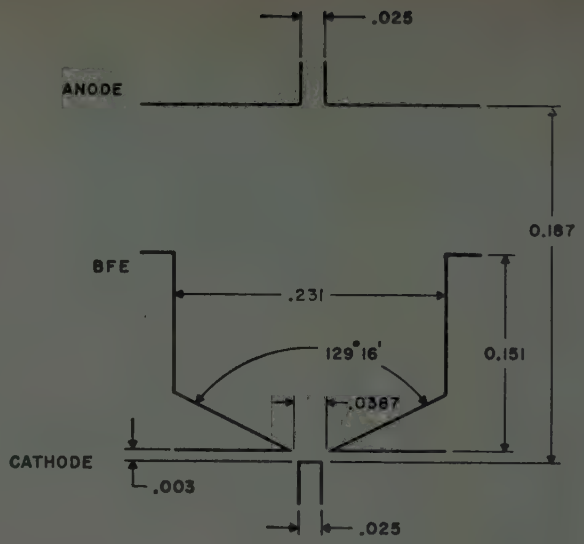

Fig. 3—Electron gun. (All dimensions in inches.)

ATTENUATION AND EFFICIENCY

At millimeter wavelengths, helix attenuation becomes sufficiently high to have a major effect on power output. Fig. 4 shows the expected relationship between these quantities. We have plotted the ratio of efficiency to the gain parameter C as a function of the ratio of L/C where L is the loss per wavelength. The intercept of the curve for zero attenuation is obtained using results of an experimental study of TWT efficiency by Cutler,[12] and the slope is determined from another experimental study of the effect of loss on efficiency by Cutler and Brangaccio.[13]

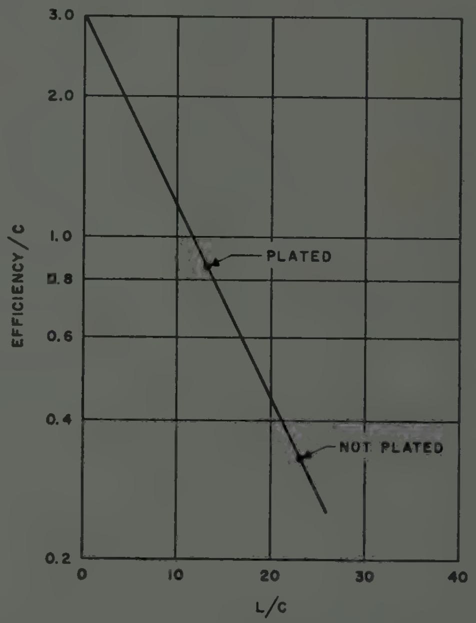

Fig. 4—Approximate relationship between traveling-wave tube efficiency and L/C.

For a molybdenum helix of the type used in the millimeter tube the L/C ratio as based on actual measured helices would be about 25. According to Fig. 4 this would result in an efficiency of about $C/3$. To reduce the L/C ratio we copper-plate the helix. With reasonable care in the plating process, we can obtain a plated surface with 0.8 the conductivity of solid copper. This would reduce the L/C ratio to about 12 and the resulting efficiency would be about 0.9 C. By plating the helix we will gain somewhat more than the factor of about 3 indicated here, since the less lossy helix will in turn dissipate less RF power. This means that the power fade caused by RF heating will be somewhat less. With a C value of 0.015 this gives us an expected electronic efficiency of about 1.4 per cent. This comparatively low value results first from the high-voltage design which results in low C, and second, from the effect of attenuation which reduces the efficiency by a factor of about 3 over that which could be obtained at low frequencies. Presumably the over-all efficiency of the tube could be raised somewhat by low-voltage collection. For the low QC value (0.07) of this tube, Cutler's experiments predict a small enough velocity spread so that collection at as low as 0.3 of the helix voltage should be feasible.

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[12] C. C. Cutler, "Nature of power saturation in traveling-wave tubes," *Bell Sys. Tech. J.*, vol. 35, pp. 841–876; July, 1956.

[13] C. C. Cutler and D. J. Brangaccio, "Factors affecting traveling wave tube power capacity," IRE TRANS. ON ELECTRON DEVICES, vol. ED-3, pp. 9–23; June, 1953.

Mechanical Design

The very small internal diameter of this helix (15 mils) and its very large length-to-diameter ratio give rise to a tube which requires a high degree of precision in its construction. Helix straightness and the alignment of gun, helix, and magnetic field axes must be maintained within a tolerance of about one-half mil over the four-inch length (*i.e.*, within an accuracy of 1 in 8000). To obtain such precision through the use of self-aligning piece parts would have required so many tight tolerances as to render the tube impractical. The problem of alignment may be viewed as two-fold: first, the concentric alignment of parts, and second, the angular alignment of their axes. We chose to obtain concentric alignment by use of optical techniques, and angular alignment by the use of a number of parallel reference surfaces. This simplified the design to the point where we could take full advantage of machining operations in which high precision is obtained relatively easily. Examples of such operations are surface grinding to produce flatness and parallelism, centerless grinding to produce constancy of diameter (although not necessarily straightness), and machining with a single lathe setting to produce concentricity of cylindrical surfaces. By extensive use of these techniques we have achieved alignment of gun, helix and magnetic field axes to within the required one-half mil without imposing tolerances tighter than one mil on absolute dimensions. By contrast, the use of precise interlocking piece parts would have required tolerances tighter than one-tenth mil to give this precision of alignment.

The helix assembly is shown in Fig. 5. The helix is wound from 2×4 mil molybdenum tape, glazed to a single wedge of dielectric, and then copper plated. This single-rod support has several advantages. First, it gives rise to structural simplicity and avoids the problem of stress due to mechanical overconstraint. Second, it minimizes the amount of dielectric in the RF fields and thus minimizes both dielectric loading and dielectric loss. Finally, the perturbation (once each turn) due to the dielectric rod introduces a stop band into the helix transmission around the frequency for which $ka=0.5$. This helps to suppress any tendency toward backward-wave oscillation.

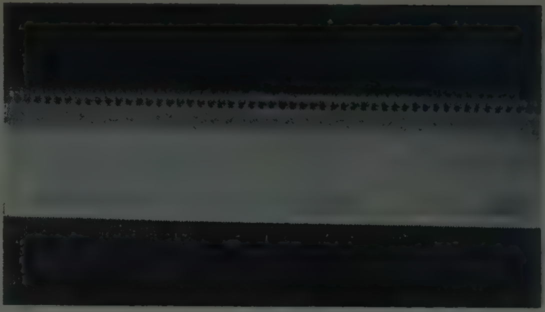

Fig. 5—Photograph of the helix glazed to dielectric rod (helix pitch is 110 TPI).

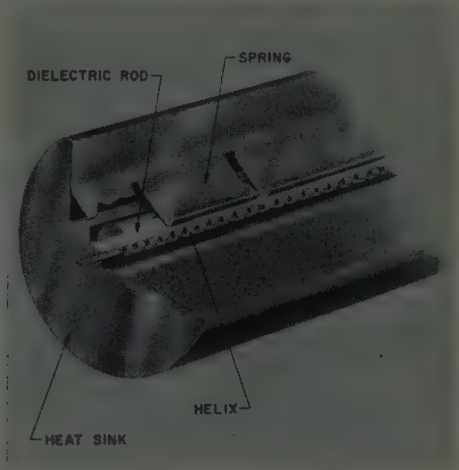

Fig. 6—Helix mounted on a heat sink (artist's rendering).

The method of supporting the helix is shown in Fig. 6. The ceramic support rod is forced into the corner of a copper block by a multiple-finger spring which contacts the rod along the entire length of the helix. This block serves as a heat sink and has a direct heat conduction path of low impedance to the outside of the vacuum envelope. The surfaces of the block against which the helix is mounted are ground accurately straight, but need not be accurately located. The spring and the ceramic rod are so designed that there is a net component of force pushing the rod flat against the bottom surface and back into the corner. The dielectric rod is anchored to the helix block at its midpoint only and is otherwise free to slide axially with respect to the copper block as required by differential expansion during bake-out. The end surfaces of the block are ground perpendicular to the two planes which form the corner against which the helix is mounted, and thus serve as precise reference surfaces for aligning the gun and magnetic field axes with respect to the helix.

The input and output matching sections which contain the waveguide-to-helix transitions, vacuum windows, and means for supporting gun or collector are mounted as shown in Fig. 7. These matching sections are brazed stack-ups of two copper disks and a steel disk. The copper disks contain the waveguide, and the steel disk serves as a magnetic pole piece. After brazing, the flat surfaces are ground accurately parallel, as suggested in Fig. 7, and the inside hole is machined accurately concentric with the outside diameter. The

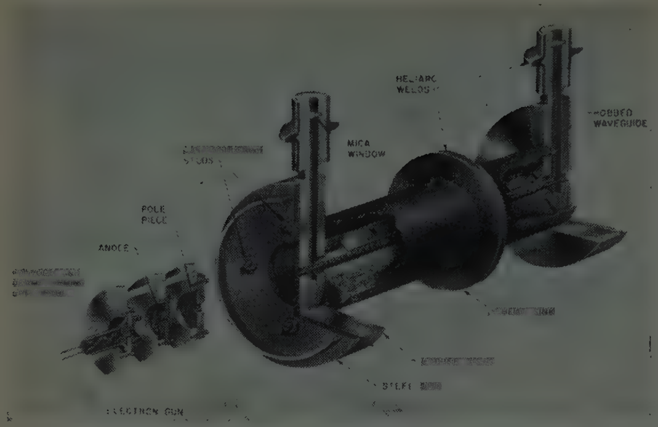

Fig. 7—Structural features of the millimeter-wave TWT (artist's rendering).

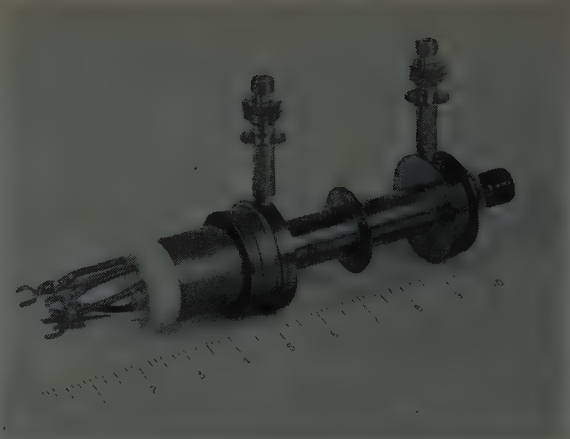

Fig. 8—Photograph of the millimeter-wave TWT.

waveguide windows are made as separate subassemblies which can be individually leak checked and tested for their microwave properties. They consist of a one-mil thick synthetic mica flake glazed to a kovar cup which, in turn, is brazed across the copper waveguide. The windows have a transmission loss of about 1 db and VSWR of about 2 db. Once a window has been found satisfactory, it is fastened against its seat in the matching block by a heliarc weld. The matching sections are located concentric with the helix by optical alignment and are then screwed to the helix block. (For simplicity these screws are not shown in Fig. 7.) The outside diameters of the pole pieces are thus concentric with the helix and can be used for aligning the tube in the magnetic field. Finally, the four-gun positioning studs are located on a circle concentric with the helix—again by optical means.

The gun assembly is shown schematically (and not to scale) on the left in Fig. 7. A subassembly of three parallel platforms glazed to four ceramic rods is first prepared. Electrodes are then placed on these platforms one at a time, aligned optically, and screwed into place. The complete gun is finally mounted on the input matching section, and positioned concentric with the helix by the studs.

The tube is completed by adding collector and stem, and by closing the vacuum envelope by means of heliarc welds. Throughout the design, care was taken in the selection of materials to insure that during thermal cycling parts did not shift as a result of differential expansion pressures. Fig. 8 shows a photograph of the completed tube and Fig. 9 shows the tube mounted in a permanent magnet. This magnet provides 1500-gauss axial field with the transverse component held to less than 1/10 per cent. The magnetic pole pieces inside the tube serve as part of the magnetic circuit and thus shield gun and collector from magnetic fields. The holes in the magnetic pole pieces determine the magnetic axis of the circuit; because they are concentric with the helix they make the magnetic axis coincident with the helix axis.

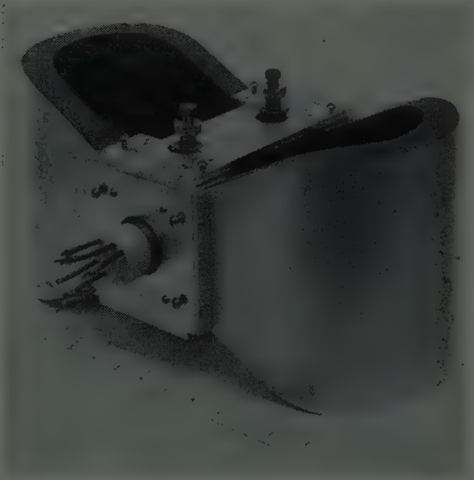

Fig. 9—Photograph of the tube mounted in a permanent magnet-focusing circuit.

Since the gun has been carefully constructed to produce a beam which is accurately coaxial with the helix, all three critical axes—beam, helix and magnetic field—have thus been made coincident, and very good focusing has been consistently obtained without the need for tedious final alignment procedures.

EXPERIMENTAL RESULTS

A total of seven tubes have given RF output powers of 100 milliwatts or more in the 5–6-mm band. Results will be presented for one of the later tubes in which several of the early problems have been eliminated. Fig. 10 shows typical curves of RF power output as a function of input power at midband for a beam current of 3 ma. These curves were taken with the helix voltage adjusted for maximum gain at low signal levels. Maximum power output at saturation is obtained at only very slightly higher helix voltages, and the resultant characteristics appear almost identical to the ones shown here.

Experiments were performed to determine the maximum output power capability of the tube. In these ex-

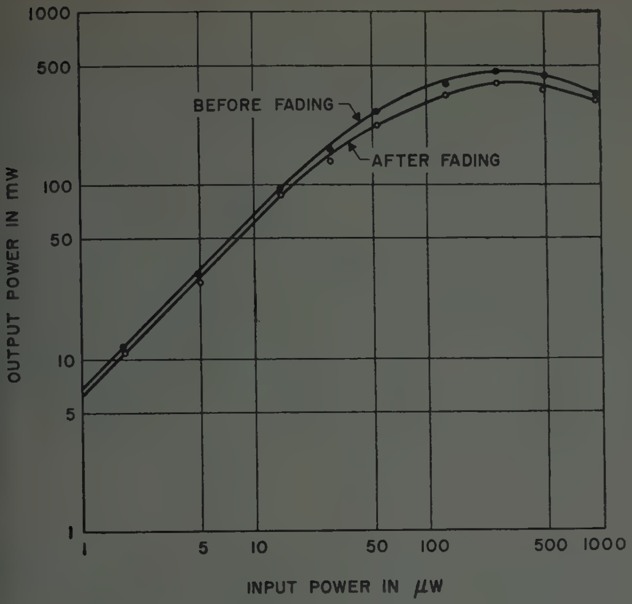

Fig. 10—Power output as a function of power input.

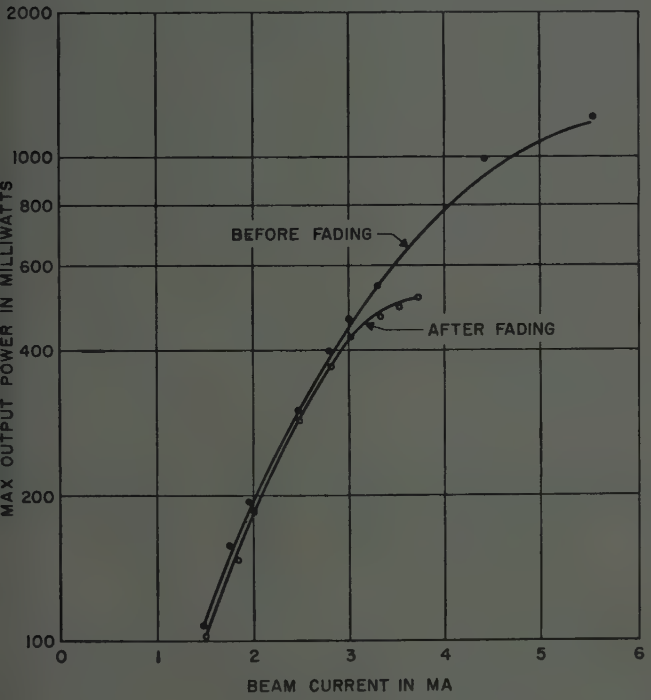

Fig. 11—Power output as a function of beam current.

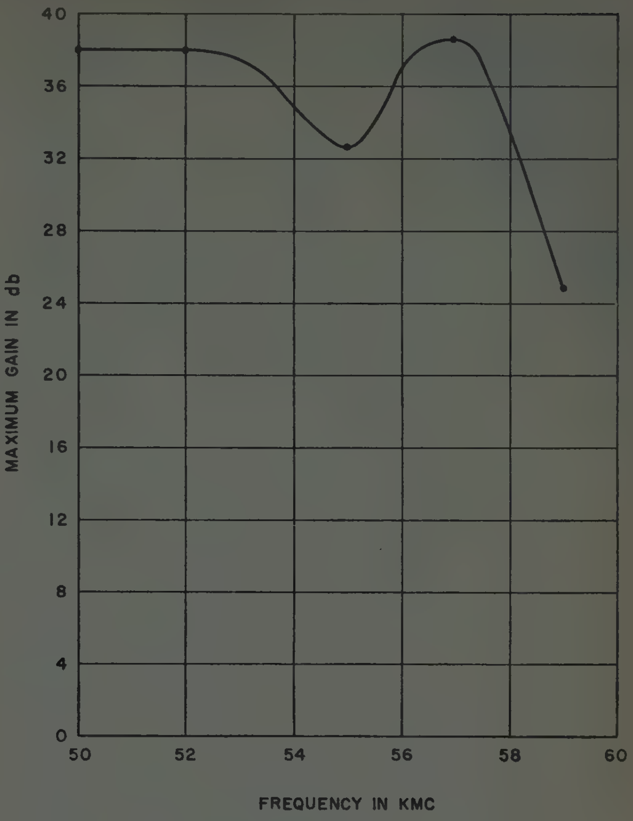

Fig. 12—Gain as a function of frequency.

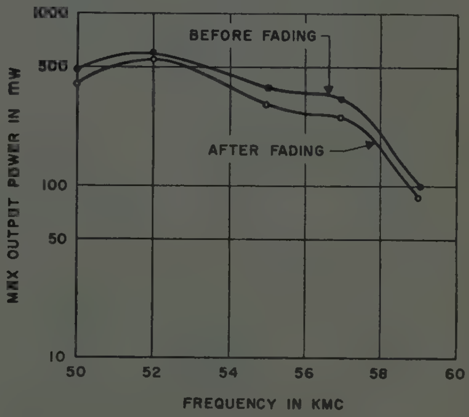

Fig. 13—Power output as a function of frequency.

periments the beam current was changed by varying both the anode and beam forming electrode voltages. The saturation power output, both before and after fading, was measured; Fig. 11 shows the results. It is seen that a power output of one watt at 5-ma beam current was obtained, but that the tube could not hold this level and faded back to about one-half watt. As discussed earlier, this fading was caused by heating of the output end of the helix by RF dissipation and the consequent increase in RF dissipation. Even at the one-watt level there was little increase in helix interception. The power output before fading is approximately proportional to the four-thirds power of beam current as expected. It should be noted that this tube had F-66 ceramic support rods, and that with the better thermal conductivity of sapphire it may be possible to maintain a considerably higher output level.

The low-level gain and the saturation power output over the band are shown in Figs. 12 and 13 for a beam current of 3 ma. The detailed shapes of these curves are largely determined by the helix-to-waveguide transducers initially used. A much improved transducer with a minimum return loss of 15 db from 50 to 60 kmc has been developed but has not yet been incorporated into a tube. With such transducers flatter characteristics will be obtained.

SCALING TO LOWER AND HIGHER FREQUENCIES

It may be interesting to speculate on the uses of the techniques developed for this tube and extensions of these techniques in high-power tubes of lower frequency. Thus, suppose we scale the present tube down in frequency to X-band. Maintaining γa, ka, and the current density constant, and allowing for the decreased attenuation at the lower frequency, one watt at 55 kmc would correspond to 72 watts at 10 kmc. To cool the helix of such a tube successfully, techniques of improving the heat transfer across the boundary between the dielectric rod and the heat sink would have to be developed beyond those used in the mm-wave tube. The CW output at X-band might be further increased to over 200 watts, at the expense of a higher voltage, by increasing ka to 0.4. As discussed before, we would be depending on the stop band at a ka of 0.5 to prevent backward-wave oscillations.

As for going to higher frequencies, it appears that an increase in ka to 0.4 (while maintaining the helix diameter the same) might permit operation at 80 kmc. Operation at a ka of 0.65—*i.e.*, above the stop band but below the first forbidden region of the helix—might permit us to go to 150 kmc. Both of these tubes would have CW output power in the range of about 100 milliwatts.

CONCLUSION

The results presented in this paper are of a preliminary nature. However, we have accumulated sufficient experience with this tube to convince us that there will be no major stumbling blocks between the point we have now reached and our ultimate objective of a long-life tube with refined and reproducible performance. By the use of the mechanical techniques described here it is possible to keep tolerances reasonably liberal even though we obtain final alignments accurate to within tenths of a mil. It should therefore be possible to construct this tube in quantity and at reasonable cost. Thus we feel that we have demonstrated the practicality of a broad-band amplifier capable of delivering power outputs of up to one watt in the 5- to 6-mm band.

ACKNOWLEDGMENT

The millimeter wave amplifier described here has benefited importantly from contributions of a number of colleagues. L. J. Speck developed the means of constructing the tiny helix which is the heart of the tube. He also developed the mica vacuum windows and was responsible for the execution of the over-all mechanical design. K. E. Schukraft of the Murray Hill Precision Room developed the technique of grinding copper which we have used extensively in the construction of the tube. G. F. Herrmann designed the electron gun and P. P. Cioffi developed the magnetic circuits. M. E. Hines made valuable suggestions with regard to the support rod and to electrical contact to the helix.

CORRECTION

H. A. Wheeler, author of "The Spherical Coil as an Inductor, Shield, or Antenna," which appeared on pages 1595–1602 of the September, 1958 issue of PROCEEDINGS, has requested that the following corrections be made to his paper.

Formula (29) on page 1600 should read:

$$p = \frac{R}{\omega L} = \left(\frac{2\pi a}{\lambda}\right)^3 \frac{1}{1 + 2/k} = \frac{V}{V_r} \frac{1}{1 + 2/k}.$$

Formula (31) on page 1600 should read:

$$\frac{3\pi^2 a' \delta^2}{2\lambda}$$

to agree with formula (3) of the author's earlier paper, reference [18].

Formula (46) on page 1602 should read:

$$n = \left(\frac{27L^2}{2\pi\mu_0{}^2 A}\right)^{1/3}.$$

The Propagation of Radio Waves of Frequency Less Than 1 kc*

E. T. PIERCE†

Summary—**The simplified mode theory of propagation in a waveguide formed by the earth and a concentric ionosphere of constant height is applied to the experimental observations of Chapman and Macario for the frequency range between 100 cps and 1000 cps. It is demonstrated that the discrepancies between the theory and the nighttime experimental results may be explained by modifying the theory and postulating an effective increase in the ionospheric height as the frequency decreases. This concept is also shown to be not necessarily incompatible with the results for day.**

INTRODUCTION

INCREASING attention has been paid of late to propagation at extra low frequencies (ELF). At these frequencies it appears that the propagation can be very simply explained in terms of a single mode travelling within the waveguide formed by the earth and a concentric homogeneous ionosphere at height h.

According to the mode theory of propagation in the form developed by Wait,[1,2] only the zero mode is of importance at ELF. After certain approximations, the attenuation coefficient α in this mode can be expressed as:

$$\alpha \approx \frac{7850}{h}\sqrt{\frac{f}{\omega_r}} \quad \text{where} \quad \omega_r = \frac{Ne^2}{m\epsilon_0\gamma}. \tag{1}$$

In (1), α is measured in decibels per 1000 km, h is in kilometers, f is the frequency, ω_r is in mks units with N and γ the electron density per m^3 and the electron collisional frequency, respectively, for the homogeneous ionosphere; the other symbols have the conventional significance. It is evident from (1) that if the simple theory applies, and h and ω_r are therefore not to be considered as dependent upon the frequency of the wave being propagated, then $\sqrt{f}/\alpha$ should be constant.

THE EXPERIMENTAL INFORMATION

Experimental values for the attenuation coefficients at ELF are regrettably scarce. The only strong natural source of signals at these frequencies is the lightning discharge, and it is from studies of the propagation of atmospherics that Chapman and Macario[3] have derived figures for the attenuation coefficients. Some values have also been obtained by Holzer, Deal, and Ruttenberg,[4] but these have not yet been published in the general literature; even the valuable information of Chapman and Macario is only available in summarized form and not in the detail that could be desired. It should perhaps be pointed out that the single station work of Chapman and Macario is not an entirely satisfactory source of data. For instance, the observations are limited to distances comparable with the wavelengths at the lower range of ELF; this implies that near field analysis should be applied. Again in single station work, as compared with investigations using several stations, the variable spectral content of the source cannot be eliminated, and it is therefore necessary to average many individual results. This procedure has both advantages and disadvantages. The conclusions drawn can never be as precise as those obtained from multi-station recording on the same atmospheric. On the other hand it is notoriously misleading in geophysics, where many quantities show considerable variations, to concentrate upon an individual example and ignore the over-all behavior.

Chapman and Macario's experimental results do not appear to have been examined on the basis of (1). Accordingly, this has been done in Fig. 1 in which two curves are plotted of $\sqrt{f}/\alpha$ against f for day and night conditions respectively, and in the frequency range of 100 cps to 1000 cps. It is apparent that during day for frequencies exceeding about 300 cps the constancy of $\sqrt{f}/\alpha$ to be expected on the simple theory is realized; at night, there is no indication of such a constancy; and both by day and by night there are divergencies for the lower frequencies. The last effect is perhaps not entirely unexpected, since (1) is really only valid for distances exceeding about one or two wavelengths, and, as already indicated, the experimental observations are limited to within 3000 km (wavelength for 100 cps). Again at distances "close" in terms of a wavelength, the electrostatic component of the field due to a lightning discharge is significant. Indeed, a combination of these influences would imply that the short range attenuation law should differ from that for greater distances. There is some suggestion of this in the results of Chapman and Macario, but the spread of the observations is too great for any precise conclusions to be drawn.

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* Original manuscript received by the IRE, May 4, 1959; revised manuscript received, December 1, 1959.

† AVCO Research and Advanced Development Division, Wilmington, Mass.

[1] J. R. Wait, "The mode theory of VLF ionospheric propagation for finite ground conductivity," PROC. IRE, vol. 45, pp. 760–767; June, 1957.

[2] J. R. Wait, "The attenuation vs frequency characteristics of VLF radio waves," PROC. IRE, vol. 45, pp. 768–771; June, 1957.

[3] F. W. Chapman and R. C. V. Macario, "Propagation of audio-frequency radio waves to great distances," *Nature*, vol. 177, pp. 930–933; May, 1956.

[4] R. E. Holzer, O. E. Deal, and S. S. Ruttenberg, "ELF propagation," *Proc. VLF Symp.*, Boulder, Colo., Paper No. 45; January, 1957.

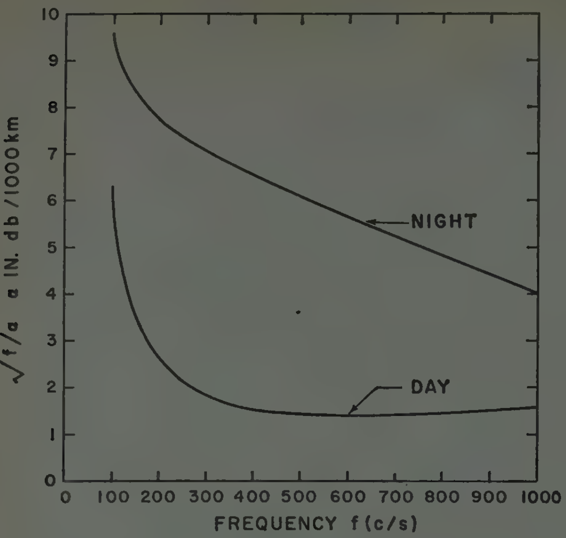

Fig. 1—Relation to frequency of Chapman and Macario's experimental values for the attenuation coefficient α.

THE REINTERPRETATION OF THE RESULTS

Night

The quantity $h\sqrt{\omega_r}$ may be estimated directly from ionospheric data for the variation of N and γ with height. The exact form of this variation is not known but the situation has been summarized by Waynick[5] who gives several references to the best available information. A combination of this data is depicted in Fig. 2, while Fig. 3 represents the variation of $h\sqrt{\omega_r}$ with height, for both day and night conditions, deduced from the curves of Fig. 2. It can be seen from Fig. 3 that $h\sqrt{\omega_r}$ increases monotonically with increasing height, but that the rate of increase is very slight by day for the range of height 71 to 77 km.

It is interesting to accept Chapman and Macario's experimental figures for $\sqrt{f}/\alpha$ from Fig. 1, and then use (1) to obtain the corresponding values of $h\sqrt{\omega_r}$ at various frequencies. In turn these values may be employed to define a series of heights since $h\sqrt{\omega_r}$ is monotonic with height. These are indicated, for frequencies at intervals of 100 cps, by the horizontal lines on the night curve A of Fig. 3; for these night results the variation within the range 100 to 1000 cps is represented quite well by the empirical relation

$$H = (89 - 0.17\sqrt{f}), \tag{2}$$

or with rather less accuracy by

$$H = \left(81.0 + \frac{85}{\sqrt{f}}\right). \tag{3}$$

H is the new height parameter.

The procedure outlined above is equivalent to postulating that the simplified waveguide theory does not apply, but by introducing the slight modification that

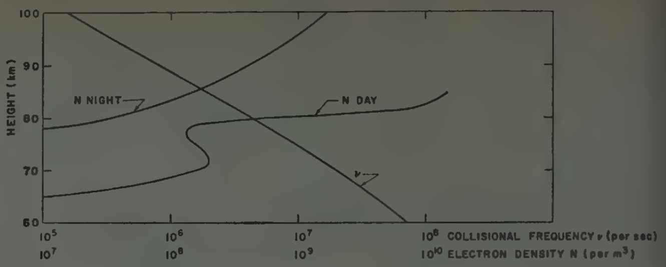

Fig. 2—Variation of electron density N and electron collisional frequency, γ with height.

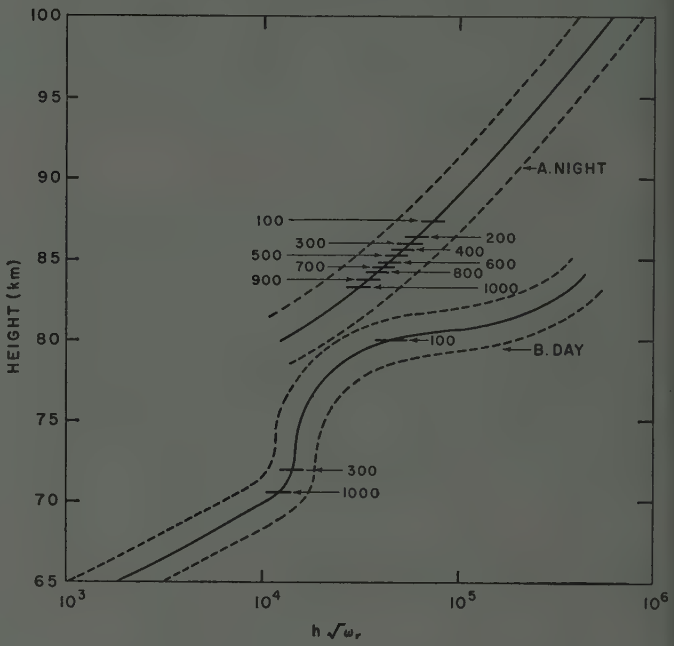

Fig. 3—Variation of $h\sqrt{\omega_r}$ with height.

h, a constant in (1), should be replaced by H which varies with frequency, a considerable measurement of agreement is obtained between theory, the experimental results, and what is known of the constants of the ionosphere. Physically the modification seems plausible. As indicated by Budden[6] one would anticipate the penetration of the fields of the waveguide modes into the ionosphere to be greater the larger the wavelength, and thus (2) and (3) for the variation of H with f are not unreasonable. Again, the two layer model of Wait[7] shows that frequencies from 8 to 18 kc are effectively reflected from the lower layer, while frequencies less than 3 kc penetrate to the higher level. Indeed, (2) and (3) may be regarded as an application to frequencies below 1 kc of an extension of the Wait two layer model; the model is now infinitely layered; that is, continuous. Eq. (3) is reminiscent of formulas associated with the skin effect, but too much significance should not be ascribed to this similarity.

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[5] A. H. Waynick, "The present state of knowledge concerning the lower ionosphere," PROC. IRE, vol. 45, pp. 741–749; June, 1957.

[6] K. G. Budden, "The propagation of very low frequency radio waves to great distances," *Phil. Mag.*, vol. 44, pp. 504–513; May, 1953.

[7] J. R. Wait, "An extension to the mode theory of VLF ionospheric propagation," *J. Geophys. Res.*, vol. 63, pp. 125–135; March, 1958.

Day

At first sight it would appear that the experimental results for day are in good agreement with simple theory using a constant height, since the quantity $\sqrt{f}/\alpha$ does not change appreciably in Fig. 1 between 300 and 1000 cps. However, consideration indicates that because $h\sqrt{\omega_r}$ is practically constant over an appreciable range in height by day (Fig. 3), the experimental results are not entirely inconsistent with the idea of a height changing with frequency as postulated in the preceding section.

The argument is as follows. First of all, to clarify matters, the values of $h\sqrt{\omega_r}$ corresponding to the observed attenuation coefficients at 100, 300, and 1000 cps, are plotted on curve B of Fig. 3. Now the graphs of Fig. 2 giving the variation of N and γ with height are by no means precise; for example, at 70 km, values of γ of between 1×10^7 and 3×10^7 collisions per second have been quoted in the past. Uncertainties of this order imply that the curves of Fig. 3 could well be displaced at least within the limits indicated by the dotted lines. Such a displacement would have relatively little influence upon the interpretation of the night results since the graph A on Fig. 3 changes little in slope. By day, however, the situation is entirely different. In particular, only a slight displacement is needed to bring the experimentally determined values of $h\sqrt{\omega_r}$ for 300 and 1000 cps on to the steepest part of curve B. It is tempting to suggest that this is indeed the case since under these circumstances a change in H of roughly 2.5 km between 300 and 1000 cps as indicated by the night results, would correspond by day to a variation of only about 5 per cent in $h\sqrt{\omega_r}$, and therefore a change also of the same order in the experimentally determined $\sqrt{f}/\alpha$. The scatter and uncertainties in experimental results such as those of Chapman and Macario are probably sufficient to obscure variations of this magnitude. Thus it is possible, without too great difficulty, to reconcile the concept of a height varying with frequency with the experimental results both by day and by night. It must be admitted, however, that if the apparent minimum of about 600 cps for $\sqrt{f}/\alpha$ by day (see Fig. 1) is a real effect, then the derived H is not monotonic with frequency, and the reinterpretation may be said to fail for the day results.

DISCUSSION

It has been pointed out how there are difficulties in the interpretation on the simple waveguide theory of the experimental results at night for the attenuation of ELF radio waves during propagation. The difficulties are removed by the physically plausible postulation that the height of the guide increases as the frequency decreases. This concept has also been shown to be not entirely inconsistent with the daytime results.

The two layer model introduced by Wait has already been mentioned. This model referred primarily to propagation in the VLF range, but Wait has also considered a second extension to the mode theory for ELF propagation, being concerned with the indication from the experimental work of Holzer, Deal, and Ruttenberg that there is a minimum of attenuation at around 100 cps. Incidentally, the first diagram in the paper by Chapman and Macario also suggests that the daytime attenuation is, if anything, less at 125 cps than at either 100 or 160 cps, although Chapman and Macario in their derived attenuation coefficients give a monotonic increase from 100 to 1000 cps. In his second model, Wait retains the concept of a waveguide with a sharply bounded edge at the lower ionosphere but adds an exponential variation of N/γ decreasing upwards within the ionosphere. Strictly speaking, this picture is untrue at least up to the maximum of electron density in the F region; effectively, however, it may be legitimate over distances comparable with a wavelength (3000 km for 100 cps), although this is not immediately evident bearing in mind the comparatively slow decrease in N above the F2 maximum indicated by Sputnik observations and by whistler results for farther from the earth, together with the uncertainties relating to the values for γ. The tapered exponential model of Wait can account for a minimum of attenuation at a frequency of the order of 100 cps and in this respect has the advantage over the approach advanced in the present paper. In general, however, the latter seems to be more effective in explaining the discrepancies, particularly at night, between Chapman and Macario's results and those anticipated on the simple theory.

It is, however, perhaps academic to pursue the development of propagation theories at these low frequencies while the experimental observations remain so scanty. Further and more detailed results are urgently needed and these could be immediately obtained in the manner of Chapman and Macario by work on atmospherics. Multistation observations would be even more valuable.

ACKNOWLEDGMENT

The author is indebted to Professor R. E. Holzer for helpful comments.

Maximum Stable Collector Voltage for Junction Transistors*

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Summary—**A study is made of the conditions for stability of junction transistors operating in the pre-avalanche breakdown region in order to establish on quantitative grounds the maximum collector voltage that can be applied to the transistor for stable operation. A method is shown by which this peak voltage can be calculated from a knowledge of the circuit configuration, mode of emitter bias, rate of heat generation, and ambient temperature.**

INTRODUCTION

OPERATION of junction transistors at high voltages has become more practical recently as a result of improved techniques which make possible devices having lower leakage currents, lower thermal resistance, and, therefore, better temperature stability. There is, however, an inherent limit to the collector junction voltage that is allowable for stable operation of junction transistors. When the collector voltage reaches a high value, a current-multiplication effect occurs within the collector junction.[1] This phenomenon may cause excessive heating, instability, and eventual breakdown.

The mechanism of avalanche breakdown involves a charge-carrier multiplication effect which results when holes and electrons attain sufficient energy because of the high electric field present, to interact with valence electrons and produce electron-hole pairs.[2] This process is cumulative and eventually results in a breakdown of the junction similar to the ionization in gas discharge tubes. The ionization rate, which increases with the electric field strength, is entirely negligible for small reverse biases, but increases rapidly at higher voltages until a critical voltage is reached at which the junction current avalanches uncontrollably. The avalanche-breakdown voltage, therefore, defines the maximum reverse bias voltage that can be applied to the collector junction under any conditions.

In the prebreakdown region, the current-multiplication effect is not sufficient to produce an avalanche breakdown of the collector junction but may have a profound effect on the stability of the transistor. As the reverse-bias collector-junction voltage is increased, the emitter to collector dc alpha increases because of the multiplication effect and may, in general, be less than, equal to, or greater than unity depending on the magnitude of the collector-junction voltage.[3] When the transistor is operated so that its alpha exceeds unity, the circuit may be unstable and produce a premature breakdown of the transistor at voltages that are considerably less than that necessary to cause an avalanche breakdown of the collector junction itself. Because the application of dc negative feedback can be used to degenerate the effective gain of the transistor, it is possible to design the circuit so that stable operation is maintained with values of alpha greatly exceeding unity. As the collector voltage approaches the avalanche breakdown voltage of the collector junction, however, the alpha becomes infinite and no amount of feedback can stabilize the collector current. The maximum reverse-bias voltage that can safely be applied to the collector junction in a given application is not fixed, therefore, but is controlled by circuit design.

The thermal stability of the transistor is also adversely affected by the multiplication phenomenon. Because the multiplication phenomenon increases the collector-saturation current as well as the current gain of the transistor, an increase in collector voltage may cause a premature thermal breakdown which would not ordinarily occur. In such cases, the breakdown is caused by thermal instability in the presence of the multiplication mechanism. The relative importance of the two effects is dependent upon such parameters as the collector-junction avalanche-breakdown voltage, dc alpha, the amount of negative feedback present in the circuit, thermal resistance, saturation current, ambient temperature, and rate of heat generation.

An analysis of the requirements for operational stability of the transistor, therefore, must include the effects both of thermal heating and of the multiplication phenomenon. In this paper, the collector-breakdown voltage is defined as the maximum collector-to-base voltage at which the transistor remains stable, regardless of whether this maximum voltage is limited by thermal runaway or by multiplication breakdown.

DERIVATION OF STABILITY CRITERION

The intrinsic dc characteristics of junction transistors in the absence of avalanche-multiplication effects and leakage currents have been described elsewhere.[4] For the

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* Original manuscript received by the IRE, April 20, 1959; revised manuscript received, October 16, 1959.

† Semiconductor and Materials Division, RCA, Somerville, N. J.

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[2] S. L. Miller, "Avalanche breakdown in germanium," *Phys. Rev.*, vol. 99, pp. 1234–1241; August, 1955.

[3] H. Schenkel and H. Statz, "Junction transistors with alpha greater than unity," PROC. IRE, vol. 44, pp. 360–371; March, 1956.

[4] J. J. Ebers and J. L. Moll, "Large signal behavior of junction transistors," PROC. IRE, vol. 42, pp. 1761–1772; December, 1954.

generalized junction transistor, such as that shown in Fig. 1, the equations are

$$I_c = -\alpha_N I_{es}(e^{qV_e/kT} - 1) + I_{cs}(e^{qV_c/kT} - 1) \qquad (1)$$

and

$$I_e = +I_{es}(e^{qV_e/kT} - 1) - \alpha_I I_{cs}(e^{qV_c/kT} - 1), \qquad (2)$$

where

I_c = collector junction current;
I_e = emitter junction current;
α_N = normal alpha, defined as the ratio of collector current to emitter current when the intrinsic collector junction is held to zero volts;
α_I = inverted alpha, defined as the ratio of emitter current to collector current when the intrinsic emitter junction is held to zero volts;
I_{es} = emitter junction diode saturation current;
I_{cs} = collector junction diode saturation current;
q/kT = where q is the electron charge, k is Boltzmann's constant, and T is absolute temperature (numerically, $q/kT = 38.5$ per volt at 25°C);
V_c = intrinsic collector junction voltage;
V_e = intrinsic emitter junction voltage.

When the collector junction is reversed-biased, qV_c/kT is less than zero, and the term $e^{qV_c/kT}$ becomes quite small. In the range of collector voltages from a few tenths of a volt to several volts, (1) and (2) are essentially independent of V_c, so that

$$I_c = -\alpha_N I_{es}(e^{qV_e/kT} - 1) - I_{cs} \qquad (3)$$

and

$$I_e = I_{es}(e^{qV_e/kT} - 1) + \alpha_I I_{cs}. \qquad (4)$$

As the reverse-bias voltage V_c is increased still further, the collector current increases because of multiplication of the charge carriers flowing across the collector junction. To account for this effect, (3) must be multiplied by a factor M which is defined as the ratio of actual current to the current which would flow if multiplication were not present. The collector current is then

$$I_c = -\alpha_N M I_{es}(e^{qV_e/kT} - 1) - M I_{cs}. \qquad (5)$$

The multiplication factor M increases with V_c in accordance with the empirical formula[1,2]

$$M = \frac{1}{1 - (V_c/V_b)^n}, \qquad (6)$$

where V_b is the ultimate avalanche-breakdown voltage of the collector junction and depends upon the impurity density in the base material, and n is a constant equal to about 3 for germanium p-n-p junction transistors and ranging from 4.6 to 6.6 for germanium n-p-n junction transistors. The observed breakdown voltage of the collector-junction diode is not always equal to V_b. Breakdown mechanisms other than the avalanche type exist (highly nonlinear surface conduction, for example), and breakdown may occur at a lower voltage. For low voltages, M is close to unity because very little carrier multiplication occurs. As the voltage increases, more carrier multiplication takes place, and the multiplication factor increases until V_c equals V_b, at which point M becomes infinite.

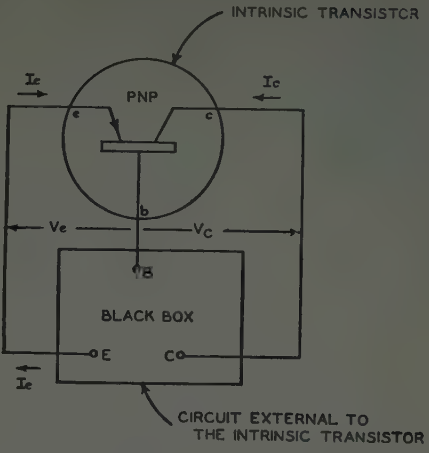

Fig. 1—Generalized transistor circuit showing the intrinsic transistor and its connection to the "black box."

In practice, M can never become infinite as this would imply an infinite rate of heat generation in the transistor. Before this point is reached, the transistor becomes thermally unstable and experiences thermal runaway. Because the actual breakdown is inherently thermal, the effect of M on the thermal stability of the transistor in the prebreakdown region is of great importance in the determination of the maximum stable collector voltage.

TEMPERATURE CHARACTERISTICS

The dc characteristics of the transistor represented by (4) and (5) are temperature-sensitive, primarily because the diode-saturation currents I_{es} and I_{cs} vary with temperature. These currents have temperature coefficients equal to $e^{\phi dT}$ where

$$\phi \cong qE_g/kT^2 \cong 0.1 \text{ per degree C at } 25^\circ \text{ C}.$$

E_g is the forbidden energy gap potential; for germanium, $E_g = 0.7$ volt. At room temperature, I_{es} and I_{cs} increase approximately 10 per cent per degree Centigrade.[5] For simplicity, these two quantities are assumed to be the only temperature-sensitive variables of the transistor.

The maximum reverse voltage is reached when a differential increment in V_c causes an infinite increase in collector current, *i.e.*, when

$$\frac{dI_c}{dV_c} = \infty,$$

where V_c is considered to be the independent variable.

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[5] H. C. Lin and A. A. Barco, "Temperature effects in circuits using junction transistors," *Transistors I*, RCA Labs., Princeton, N. J., pp. 369–402; March, 1956.

Taking the total differentials of (4) and (5) yields

$$dI_c = \frac{I_c}{M}\,dM + \phi I_c dT - \frac{q}{kT}\,\alpha_N M I_{es}(e^{qV_e/kT})dV_e \qquad (7)$$

and

$$dI_e = \phi I_e dT + \frac{q}{kT}\,I_{es}(e^{qV_e/kT})dV_e, \qquad (8)$$

where

$$dM = \frac{nM(M-1)}{V_c}\,dV_c.$$

If it is assumed that under dc conditions the junction is allowed to attain thermal equilibrium at each point of the characteristic, the heat generated is equal to the heat dissipated from the junction, and Newton's law of cooling ($dT/dP = s$) is valid. Then,

$$dT \cong sV_c dI_c, \qquad (9)$$

where s is the thermal resistance in °C/watt.

Eqs. (7)–(9) describe the effect on the intrinsic transistor of differential changes in the variables V_c, I_c, V_e and T. Any extrinsic effects, such as leakage resistance or base spreading resistance, may be included in the external circuit of the transistor. It is assumed that the external circuit of the transistor contains only constant resistances and voltage sources. When, as shown in Fig. 1, the circuit external to the intrinsic transistor is considered as contained in a "black box" having the same terminal currents and voltages as the transistor,

$$dI_e = \left.\frac{\partial I_e}{\partial I_c}\right|_{V_e} dI_c + \left.\frac{\partial I_e}{\partial V_e}\right|_{I_c} dV_e \qquad (10)$$

or

$$dI_e = -\beta_{ec} dI_c - (1/R_{eb})dV_e, \qquad (11)$$

where

$$\beta_{ec} = -\left.\frac{\partial I_e}{\partial I_c}\right|_{V_e} \qquad (12)$$

$$1/R_{eb} = -\left.\frac{\partial I_e}{\partial V_e}\right|_{I_c \text{ constant}} \qquad (13)$$

The circuit parameters R_{eb} and β_{ec} describe the properties of the linear network contained in the "black box." It is evident that R_{eb} and β_{ec} are completely independent of the properties of the intrinsic transistor. R_{eb} is the dc resistance of the "black box" measured between the emitter and base terminals with the collector terminal "floating," and with the voltage sources replaced by thei internal resistances, as shown in Fig. 2. β_{ec} is the dc current transfer ratio of the "black box" from the collector to emitter terminals with the voltage sources again replaced by their internal resistances and with the emitter and base terminals short-circuited as shown in Fig. 3. Another useful circuit parameter is the current transfer ratio from collector to base, β_{bc}, which is measured in a manner similar to β_{ec}.

The circuit shown in Fig. 4 can be used as an example. It is evident on inspection that

$$R_{eb} = R_e + R_b + r_{bb'}, \qquad (14)$$

$$\beta_{ec} = \frac{R_b + r_{bb'}}{R_b + R_e + r_{bb'}}, \qquad (15)$$

$$\beta_{bc} = \frac{R_e}{R_b + R_e + r_{bb'}}. \qquad (16)$$

In general,

$$\beta_{bc} + \beta_{ec} \equiv 1. \qquad (17)$$

Eqs. (7), (8), (9) and (11) may be solved for dI_c/dV_c, thus eliminating the variables dV_e, dI_e and dT. The solution can be obtained by inspection with the aid of the signal-flow graph representation shown in Fig. 5:

$$\frac{dI_c}{dV_c} = \frac{[n(M-1)I_c/V_c][1 + (q/kT)R_{eb}I_{es}e^{qV_e/kT}]}{1 - s\phi V_c I_c + (q/kT)R_{eb}I_{es}e^{qV_e/kT}[1 - \beta_{ec}\alpha_N M - s\phi V_c(I_c + \alpha_N MIe)]}. \qquad (18)$$

The term $(I_c + \alpha_N M I_e)$ is equal to MI_{co} where I_{co} is the reverse-biased collector-current of the transistor at low voltages ($M = 1$), measured with the emitter floating. By substitution, (18) becomes

$$\frac{dI_c}{dV_c} = \frac{[n(M-1)I_c/V_c][1 + (q/kT)R_{eb}I_{es}e^{qV_e/kT}]}{1 - s\phi V_c I_c + (q/kT)R_{eb}I_{es}e^{qV_e/kT}[1 - \beta_{ec}\alpha_N M - s\phi V_c M I_{co}]}. \qquad (19)$$

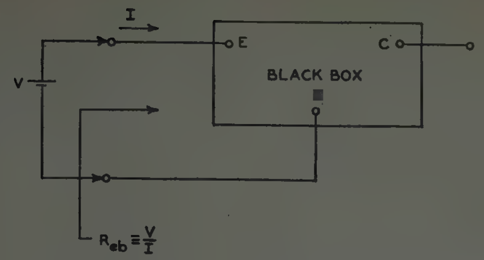

Fig. 2—Resistance R_{eb} of the "black box."

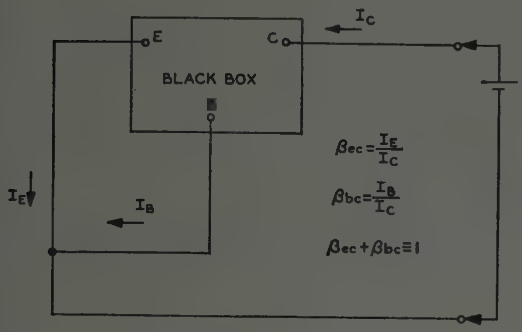
I_C
E
C
BLACK BOX
B
$\beta_{ec} = \frac{I_E}{I_C}$
$\beta_{bc} = \frac{I_B}{I_C}$
$\beta_{ec} + \beta_{bc} \equiv 1$
I_E
I_B

Fig. 3—Current transfer ratio of the "black box."

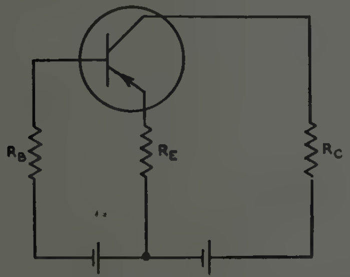

Fig. 4—DC circuit of a typical transistor stage.

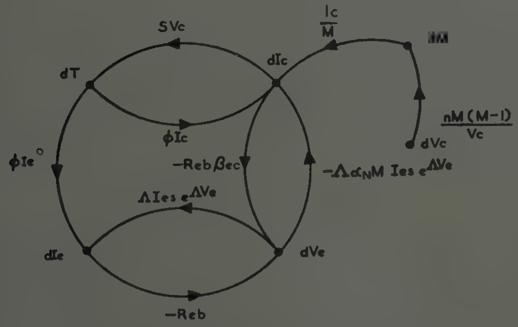

Fig. 5—Signal flow graph, $\Lambda \equiv q/kT$.

The peak reverse-bias collector voltage is reached when $dI_c/dV_c = \infty$ or when the denominator of (19) approaches zero,

$$1 - s\phi V_c I_c + (q/kT) R_{eb} I_{es} e^{qV_e/kT} \cdot [1 - \alpha_N M \beta_{ec} - s\phi V_c M I_{co}] = 0. \quad (20)$$

Eq. (20) is the stability criterion from which the maximum stable collector voltage can be derived under various operating conditions.

Determination of the Maximum Stable Collector Voltage in the Absence of Thermal Heating Effects

When the thermal resistance of the transistor is small enough, the maximum reverse-bias voltage can be derived from (20) by setting s equal to zero which gives

$$1 + (q/kT) R_{eb} I_{es} e^{qV_e/kT} [1 - \beta_{ec} \alpha_N M] = 0. \quad (21)$$

Eq. (21) is then solved for M to determine the amount of multiplication required to make the circuit unstable,

$$M = \frac{1}{\alpha_N \beta_{ec}} \left[\frac{1 + (q/kT) R_{eb} I_{es} e^{qV_e/kT}}{(q/kT) R_{eb} I_{es} e^{qV_e/kT}} \right]. \quad (22)$$

The collector-to-base voltage corresponding to M is found by solving (6) and (22) for V_c,

$$V_{cm} = V_b \left[\frac{1 + [(q/kT) R_{eb} I_{es} e^{qV_e/kT}][1 - \alpha_N \beta_{ec}]}{1 + [(q/kT) R_{eb} I_{es} e^{qV_E/kT}]} \right]^{1/n}, \quad (23)$$

where V_{cm} is the value of V_c above which the circuit becomes unstable.

There are two sufficient conditions for which the circuit can be stabilized for all values of V_c up to V_b. These conditions are that

$$(q/kT) R_{eb} I_{es} e^{qV_e/kT} \ll 1, \quad (24)$$

or that

$$\alpha_N \beta_{ec} \ll 1. \quad (25)$$

When either of these conditions is satisfied, the collector voltage must approach the avalanche-breakdown voltage of the collector junction in order to produce breakdown. Condition (24) is satisfied if a reverse-bias voltage of a few tenths of a volt is maintained across the emitter junction, or if the dc circuit resistance between the intrinsic base-to-emitter terminals R_{eb} is made sufficiently small so that the intrinsic emitter-junction voltage is held constant. The condition given by (25) requires that the current-feedback factor β_{er} be small, *i.e.*, that the ratio of series base resistance to emitter resistance be small. Either of these conditions tends to stabilize the emitter current and thereby yield a breakdown voltage approaching V_b.

When the circuit conditions are such that the emitter junction is forward biased through a dc source resistance R_{eb} of sufficient magnitude for the voltage drop across base and emitter circuit resistances to exceed a few tenths of a volt, then

$$(q/kT) R_{eb} I_{es} e^{qV_e/kT} [1 - \alpha_N \beta_{ec}] \gg 1. \quad (26)$$

Under these conditions, the breakdown voltage becomes independent of the emitter-junction bias (V_e or R_{eb}), and depends almost entirely on the amount of feedback present in the circuit. Breakdown now occurs when $\alpha_N M\beta_{ec}=1$. The maximum stable collector voltage is now equal to the multiplication-breakdown voltage, $V_{\alpha M\beta}$. Combining (23) and (26) yields

$$V_{\alpha M\beta} = V_b/(S_f)^{1/n} = V_{cm}\Big]_{\substack{s=0\\ \alpha_N M\beta_{ec}=1}}, \tag{27}$$

where S_f is defined as the stability factor,[6]

$$S_f = \frac{1}{1-\alpha_N\beta_{ec}}. \tag{28}$$

The value of the stability factor S_f is of great importance, therefore, in determining the multiplication breakdown voltage. For numerical calculations, it is more convenient to express S_f in the form

$$S_f = \frac{1+\alpha_{cb}}{1+\alpha_{cb}\beta_{bc}}, \tag{29}$$

where

$$\alpha_{cb} \equiv \frac{\alpha_N}{1-\alpha_N} \tag{30}$$

is the low-voltage transistor current gain from base to collector, and

$$\beta_{bc} \equiv 1 - \beta_{ec} \tag{31}$$

is the current-feedback factor from collector to base in the circuit, as defined previously.

It is evident that the stability factor approaches its maximum value as the collector-to-base feedback factor β_{bc} is made small relative to $1/\alpha_{cb}$. The breakdown voltage for this circuit condition approaches $V_{\alpha M}$ where

$$V_{\alpha M} = \frac{V_b}{(1+\alpha_{cb})^{1/n}} \equiv V_{cm}\Bigg]_{\substack{\alpha_N M=1\\ s=0\\ \beta_{ec}=1}}. \tag{32}$$

This breakdown voltage occurs when $\alpha_N M$ equals unity, which represents the least stable circuit condition. V_c need only be sufficient to increase M from unity to $1/\alpha_N$ to initiate breakdown where α_N ranges from about 0.95 to 0.99 in junction transistors.

As the collector-to-base feedback factor, β_{bc} is made large relative to $1/\alpha_{cb}$, the value of S_f approaches unity and the breakdown voltage again approaches that of the collector junction V_b and corresponds to an infinite value of M. Thus, in the absence of thermal heating, the breakdown voltage $V_{\alpha M\beta}$ can approach its maximum value V_b as the circuit stability factor approaches unity or when the emitter junction is reversed biased or "floating." In the intermediate case, where the emitter junction is not biased sufficiently in either polarity, conditions (24), (25) and (26) do not apply, and V_{cm} has a value which must be calculated directly from (23). Thus, by changing the circuit-stability factor or the mode of bias of the emitter junction, the multiplication breakdown can be controlled from V_b to $V_b/(1+\alpha_{cb})^{1/n}$, a ratio as large as four to one.

As previously explained, it may not be possible to measure V_b directly in practice because of surface-breakdown mechanisms which may occur at voltages lower than V_b. It is more desirable, therefore, to express $V_{\alpha M\beta}$ in terms of $V_{\alpha M}$ rather than V_b. Combining (27) and (32) gives

$$V_{\alpha M\beta} = V_{\alpha M}\left[\frac{1+\alpha_{cb}}{S_f}\right]^{1/n}. \tag{33}$$

When this equation is combined with (29), a more convenient form of (27) results:

$$V_{\alpha M\beta} = V_{\alpha M}(1+\alpha_{cb}\beta_{bc})^{1/n}. \tag{34}$$

Maximum Stable Collector Voltage When Only Thermal Effects are Considered

When avalanche-multiplication effects within the collector junction are negligible (at low collector voltages), the maximum collector voltage is limited by the onset of thermal runaway. The conditions for thermal stability of the transistor at low voltages can be investigated by using the stability criterion given by (20) with M equal to unity. Under normal operating conditions, the emitter junction is forward biased so as to satisfy (26); (20) reduces to

$$\frac{1}{S_f} - s\phi V_c I_{co} = 0. \tag{35}$$

The collector saturation current I_{co} has approximately the same temperature coefficient as I_{es} and I_{cs} and increases at a rate of about 10 per cent per degree Centigrade so that at junction temperature T,

$$I_{co} = I_{so}e^{\phi(T-T_o)}, \tag{36}$$

where I_{so} is the value of I_{co} at temperature T_o. Under equilibrium conditions, the junction temperature rises above the sink temperature by an amount equal to the power dissipated times the thermal resistance,

$$T - T_s = sP, \tag{37}$$

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[6] R. F. Shea, "Transistor operation: stabilization of operating points," Proc. IRE, vol. 40, pp. 1435–1437; November, 1952.

where T_s is the temperature of the heat sink. When (35)–(37) are combined, the maximum thermally stable collector voltage is found to be given by

$$V_{cm} = V_s e^{-s\phi P}, \tag{38}$$

where

$$V_s = \frac{1}{s\phi S_f I_{so} e^{\phi(T_s - T_o)}} \cdot \tag{39}$$

It is evident that in the absence of multiplication effects, the maximum collector voltage that can be safely applied to the transistor decreases exponentially with power dissipation and is inversely proportional to the thermal resistance, stability factor, and saturation current I_{co} measured at sink temperature.

Determination of Maximum Stable Collector Voltage When Multiplication and Thermal Effects are Considered

When both heating and multiplication effects are present, the maximum collector voltage may again be determined from the stability criterion given by (20) with M greater than unity and s different from zero. Under normal operating conditions the emitter junction s forward biased so as to satisfy (26); the stability criterion now becomes

$$1 - \alpha_N M \beta_{ec} - s\phi V_{cm} M I_{co} = 0, \tag{40}$$

which can be rearranged as

$$V_{cm} = \frac{1 - \left[\dfrac{1 - 1/M}{1 - \beta_{ec}\alpha_N}\right]}{\left[\dfrac{s\phi I_{co}}{1 - \beta_{ec}\alpha_N}\right]} \cdot \tag{41}$$

When (41), is combined with (6), (27), (28) and (39),

$$V_{cm} = [1 - (V_{cm}/V_{\alpha M\beta})^n] V_s e^{-s\phi P}, \tag{42}$$

where $V_{\alpha M\beta}$ and V_s are defined by (27) and (39), respectively.

The stability criterion given by (42) is represented graphically in Fig. 6 for $n = 3$. With the aid of this graph, t is possible to determine the maximum stable collector voltage when both multiplication and thermal effects are significant. This graph expresses the ratio $V_{cm}/V_{\alpha M\beta}$ n terms of normalized power dissipation, $s\phi P$, with a running parameter $V_s/V_{\alpha M\beta}$. When the thermal runaway voltage $V_s e^{-s\phi P}$ is large relative to the value of the multiplication breakdown voltage $V_{\alpha M\beta}$ the maximum stable collector voltage is limited by the multiplication mechanism, and the value of V_{cm} approaches that given by (27). As the thermal runaway voltage $V_s e^{-s\phi P}$ is made small relative to the multiplication breakdown $V_{\alpha M\beta}$ the maximum stable collector voltage becomes thermally limited and the value of V_{cm} approaches that given by (38). V_{cm} now tends to decrease exponentially with power dissipation. This decrease is caused by I_{co} increasing with junction temperature. If the thermal resistance is decreased, the rise in junction temperature required to dissipate the generated heat is reduced and, therefore, the value of the maximum stable collector voltage is increased.

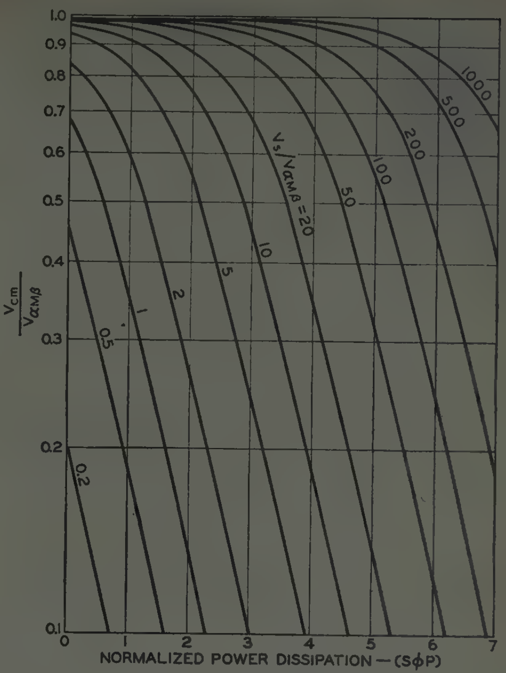

Fig. 6—Derating curves for determining maximum stable collector voltage for $n = 3$.

Illustrative Example

The following example illustrates the calculation of the maximum stable collector voltage that can be applied to a p-n-p transistor based on a knowledge of the circuit configuration, mode of emitter bias, rate of heat dissipation, and ambient temperature.

The transistor is the circuit shown in Fig. 4 is assumed to have the following characteristics:

Thermal resistance, s	1.7 °C/watt
Empirical exponent, n	3.0
Collector-to-base alpha, α_{cb}	75
Saturation current, I_{so}	50 μamps
measured at temperature, T_o	25°C
Temperature coefficient of I_{so}, ϕ	0.1 per °C
Breakdown voltage for $\alpha_{cb}R_e/R_b \ll 1$, $s = 0$; $V_{\alpha M}$	40 volts
Base-lead resistance, $r_{bb'}$	39 ohms.

It is also assumed that the transistor is forward biased so that (26) is satisfied and is operating under the following conditions:

Heat-sink temperature, T_s...........	45°C
Power dissipation, P................	13.5 watts
Emitter-circuit resistance, R_e.........	1 ohm
Base-circuit resistance, R_b............	10 ohms.

The feedback factor from collector to base β_{bc} is found by considering the "black box" equivalent circuit shown in Fig. 7. By inspection,

$$\beta_{bc} = I_B/I_C = \frac{R_E}{R_E + R_B + r_{bb'}} = \frac{1}{1 + 10 + 39} = 0.02.$$

From (29), the stability factor is

$$S_f = \frac{1 + \alpha_{cb}}{1 + \alpha_{cb}\beta_{bc}} = \frac{1 + 75}{1 + (75)(0.02)} = 30.$$

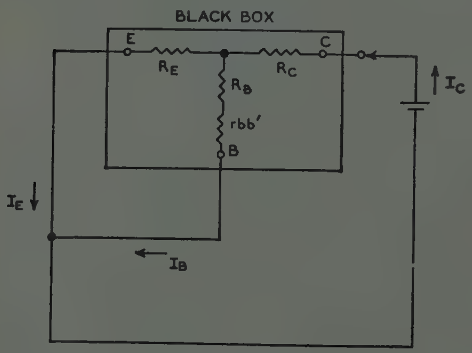

Fig. 7—Current transfer ratio of the "black box" of of the circuit shown in Fig. 4.

The breakdown voltage in the absence of thermal heating is given by (34):

$$V_{\alpha M\beta} = V_{\alpha M}(1 + \alpha_{cb}\beta_{bc})^{1/n}$$
$$= 40(1 + 75 \times 0.02)^{1/3} = 54 \text{ volts}.$$

The value of V_s is given by (39):

$$V_s = 1/[s\phi S_f I_{so} e^{\phi(T_s - T_o)}]$$
$$= 1/[(1.7)(0.1)(30)(50 \times 10^{-6})e^{0.1(45-25)}]$$
$$= 530 \text{ volts}.$$

Therefore,

$$V_s/V_{\alpha M\beta} = 530/54 \cong 10.$$

The power dissipated is 13.5 watts, hence

$$s\phi P = (1.7)(0.1)(13.5) = 2.3.$$

Once the values of $V_s/V_{\alpha M\beta}$ and $s\phi P$ have been computed, the maximum stable collector voltage V_{cm} is found directly from the graph of Fig. 6. In this case $V_{cm}/V_{\alpha M\beta}$ is found to be 0.68, or $V_{cm} = 37$ volts.

When the maximum stable collector voltage is computed neglecting thermal effects, a value

$$V_{cm}]_{s=0} = 54 \text{ volts}$$

is obtained which is the alpha multiplication breakdown voltage $V_{\alpha M\beta}$. When the maximum stable collector voltage is computed neglecting alpha multiplication, a value

$$V_{cm}]_{M=1} = V_s e^{-s\phi P} = 530e^{-(1.7)(0.1)(13.5)} \doteq 53 \text{ volts}$$

is obtained. A collector voltage equal to say 45 volts appears to be well within both stable limits considering the effects separately. This example, however, demonstrates a considerable degradation of the expected maximum stable collector voltage caused by the interaction of both alpha multiplication and thermal effects simultaneously present. In spite of the fact that a collector voltage of 45 volts exceeds neither the multiplication breakdown voltage (54 volts) nor the thermal runaway voltage (53 volts), it does exceed the combined derated voltage limit of 37 volts obtained from the graph of Fig. 6 and would result in instability and eventual destruction of the transistor.

EXPERIMENTS

Three experiments were performed in order to verify the predictions of the above theory. The first of these was designed to verify (6) and thereby measure the value of the empirical constant n. Substitution of this value of n into (27) defines the relationship between the alpha multiplication-breakdown voltage $V_{\alpha M\beta}$ and the circuit stability factor S_F. The second experiment was therefore designed to verify whether (27), with the value of n determined above, actually predicts the measured values $V_{\alpha M\beta}$ vs S_F. The details of the experimental procedure employed for these measurements and the results obtained are described below. Finally, the maximum collector voltage derating curve of Fig. 6 was measured and compared with theory for an RCA developmental germanium *p-n-p* junction transistor. These results are plotted in Fig. 13.

A. Measurement of n—Verification of (6)

The value of n can be determined experimentally by plotting the measured quantity $(M-1)/M$ vs collector junction voltage V_c to a log-log scale. Eq. (6) indicates that this function can be represented by a straight line of slope n. Furthermore, extrapolation of this line to the point where the value of $(M-1)/M$ equals unity should yield the collector junction avalanche breakdown voltage V_b which corresponds to an infinite value of M.

The measurement of $(M-1)/M$ was accomplished by measuring the ratio of the small signal base current to the collector currents as shown in Fig. 8. The base current may be found from (4) and (5) as follows:

$$I_b = -(I_c + I_e) \equiv I_c\left[\frac{1-\alpha_N M}{\alpha_N M}\right] + \frac{I_{co}}{\alpha_N}. \qquad (43)$$

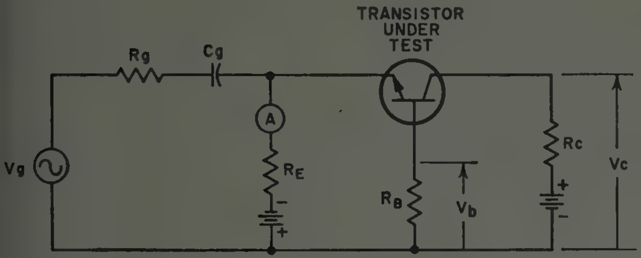

Fig. 8—A circuit for the measurement of n.

If the resistances Rc and R_B are small, then the ratio of the small signal base current to collector current is given by

$$\left|\frac{\partial I_b}{\partial I_c}\right| = \frac{R_C}{R_B}\left|\frac{V_b}{V_c}\right| = \left|\frac{\alpha_N M - 1}{\alpha_N M}\right|, \qquad (44)$$

which may be measured as a function of the dc collector junction voltage V_c. After measuring α_N (at some low voltage) the value of $(M-1)/M$ may then be computed.

Employing the above technique, the variation of $(M-1)/M$ was measured as a function of V_c with the emitter current held constant, using an RCA developmental n-p-n silicon transistor. The results which are shown plotted in Fig. 9, indicate a straight line having a slope of n equal to 4.8 and V_b equal to 195 volts.

B. Measurement of $V_{\alpha M\beta}$ vs S_F—Verification of (27)

Eq. (27), which expresses the multiplication breakdown voltage $V_{\alpha M\beta}$, as a function of the circuit stability factor S_F was verified experimentally using the circuit shown in Fig. 10.

The circuit stability factor S_F of the circuit under test was varied by changing the ratio of R_E to R_B. The multiplication breakdown voltage $V_{\alpha M\beta}$ of the circuit under test may be defined as the collector-to-base voltage necessary to produce an ac null voltage across resistance R. At this collector voltage, the current through R no longer controls the collector current. At higher collector junction voltages, the incremental current gain of the circuit under test is greater than unity and would result in unstable operation if the emitter current were not limited by R_E. Hence this voltage represents the alpha multiplication-breakdown voltage $V_{\alpha M\beta}$ for the circuit under test. The over-all circuit should, of course, have a low value of stability factor to insure over-all stability.

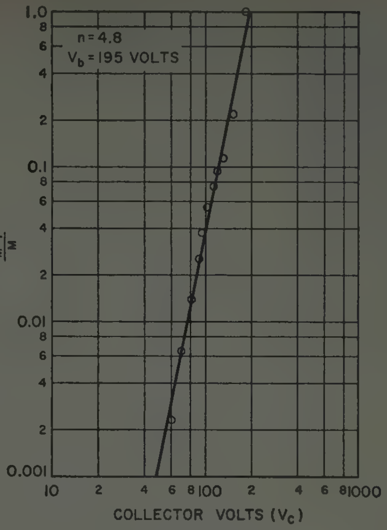

Fig. 9—Measured values of $(M-1)/M$ vs V_{cb} for an RCA developmental n-p-n silicon transistor (see Fig. 8).

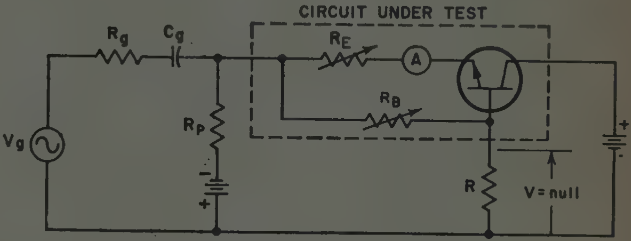

Fig. 10—Circuit for the measurement of $V_{\alpha M\beta}$ of the transistor circuit shown in the dotted box.

Fig. 11 shows a plot of measured values of $V_{\alpha M\beta}$ as a function of S_F. The stability factor was calculated for the circuit under test using (29). When plotted to a log-log scale, (27) should be expressible as a straight line having a slope of $-1/n$. Extrapolation of this line to the point where S_F equals unity (open emitter) should likewise yield the avalanche breakdown voltage of the collector junction, V_b. As is evident from the experimental curve, a straight line is obtained corresponding to the same value of n determined above ($n=4.8$) and by extrapolation indicates a collector junction breakdown voltage, $V_b=185$ volts. The value of V_b obtained using an electronic curve tracer was 190 volts. It should be mentioned that excellent experimental agreement was also obtained for p-n-p germanium transistors.

C. Measurement of the Maximum Stable Collector Voltage Derating Characteristic (42)

Fig. 12 shows a comparison between measured and predicted values of normalized maximum stable collector voltage, $V_{cm}/V_{\alpha M\beta}$, vs normalized power dissipation $s\phi P$ for an RCA developmental *p-n-p* germanium transistor. The "calculated" curve is based on the value of $n=4.0$ which was determined from measured values of $(M-1)/M$ vs V_c for this transistor (see Fig. 13).

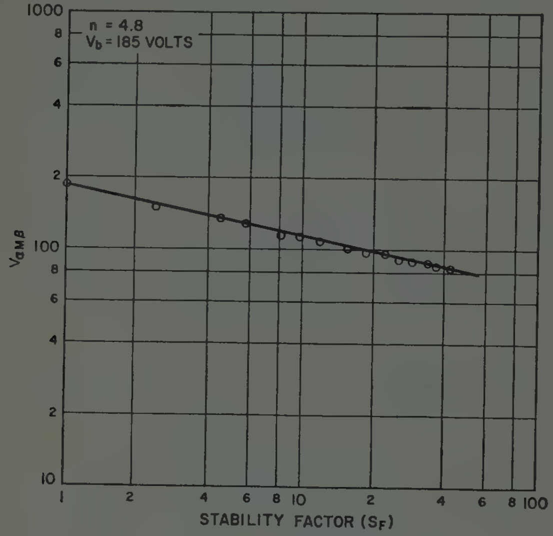

Fig. 11—Measured values of alpha multiplication breakdown voltage $V_{\alpha M\beta}$ vs circuit stability factor S_f for an RCA developmental *n-p-n* silicon transistor (see Fig. 9).

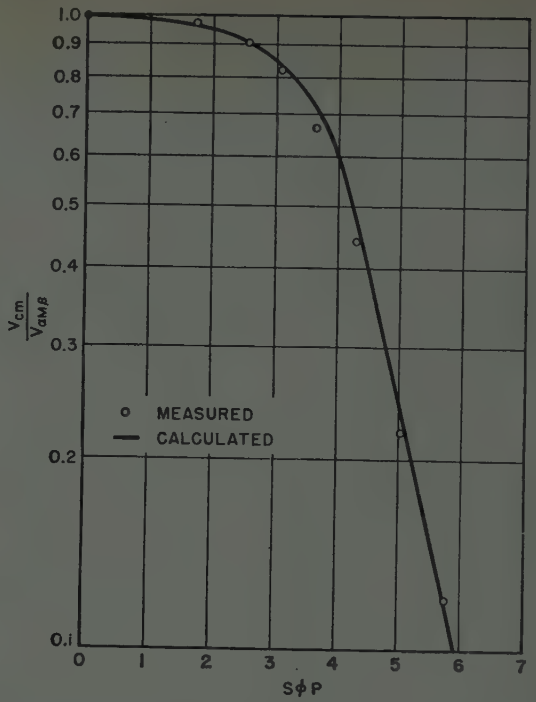

Fig. 12—Comparison between measured and predicted values of normalized maximum stable collector voltage $V_{cm}/V_{\alpha M\beta}$ vs normalized power dissipation $s\phi P$ for an RCA developmental *p-n-p* germanium transistor. (The "calculated" curve is based on $n=4.0$ as determined in Fig. 13.)

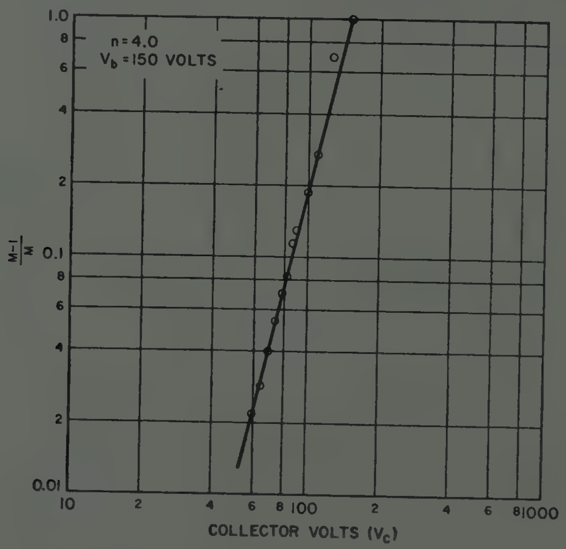

Fig. 13—Measured values of $(M-1)/M$ vs V_c for an RCA developmental *p-n-p* germanium transistor.

Ionospheric Models as an Aid for the Calculation of Ionospheric Propagation Quantities*

A. H. DE VOOGT†, MEMBER, IRE

Summary—**This paper is a continuation of a study announced in previous paper by the author [1]. Results are given in the form of urves, and a comparison is made with ionograms. The important inluence of radiation angle on the MUF (maximum usable frequency) s shown.**

A large enough number of adequate models (60 to 100) might be aluable to the radio engineer for prediction and design purposes.

I. INTRODUCTION

THE propagation path of decametric waves in the ionosphere can be calculated exactly if the electronic distribution is known. For this purpose onospheric models consisting of E and F_2 layers of various critical frequencies have been composed. The maximum of ionization is supposed to be at 110 km for the E layers and at 400 or 200 km for the F_2 layers. The onization curves, which start at a height of 70 km for all models, have the form shown in Fig. 1, beginning with a parabola up to half the maximum of the layer and ending with the top of an antiparabola in the E maximum and in the F_2 maximum. The parabolas are in fact third-degree curves which for the part considered have practically parabolic form (see previous articles on this subject [1], [2]).

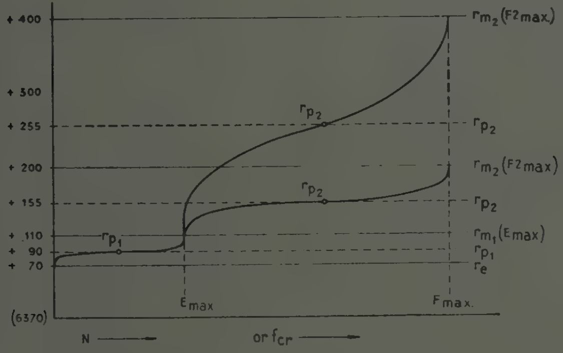

Fig. 1—N or f_{cr} as a function of r.

From the model calculations not only interesting oblique incidence results can be obtained, but it is also possible to draw vertical incidence diagrams (ionograms) for comparison with practical ionograms obtained from ionospheric sounding stations. This comparison gives an indication of which ionospheric model represents, in the best possible way, the ionosphere that actually exists at the given moment. The method of using ionospheric models will have to be classified as an approximation to actual conditions, but undoubtedly it gives interesting and unexpected results of the behavior of radio propagation under normal conditions. Furthermore, it seems probable that some general rules might be derived from the results.

The formulas used for the calculations are very complicated and are given elsewhere, together with all results and curves [10].

II. THE IONOSPHERIC MODELS

Extensive calculations have been made for a series of 36 ionospheric models consisting of E layers at 110 km with critical frequencies of 2, 3, and 4 MHz and of F_2 layers at 200 or 400 km with critical frequencies of 2, 3, 4, 6, 8, 10, 12, and 14 MHz.

For each model, the parameters to calculate "hop" length, maximum height, traveling times, etc., are a series of 15 different radiation angles, including vertical incidence, and 9 frequencies.

The calculations, which have been made by electronic computers, are based on the formulas given by the author in previous papers [1], [2]. The ionization curves are third-degree equations with the earth center as origin: they have practically a parabolic form for that ionospheric part above the earth which is actually being considered.

Fig. 1 gives the electronic distribution for an ionospheric model. The E layer starts at 70 km parabolically up to r_{p_1} at 90 km, half-way between 70 km and the maximum at 110 km. At r_{p_1} the curve changes into a second parabolic curve and ends at the E maximum with different critical frequencies (see Table I, the 36 ionospheric models used for the purpose). Then, again with a third parabola, the ionization increases up to half E and F_2 maximum at 155 or 255 km, depending on whether the F_2 maximum height is chosen as 200 or 400 km. A fourth parabola terminates the curve in the F_2 maximum. Other models with F_2 maximum at 300 km, and also models with E_1, F_1 and F_2 layers are in preparation.

The points r_{p_1} and r_{p_2}, where the parabolas change smoothly into antiparabolas, have been chosen at half the maximum heights. It is also possible to choose any other proportion differing from unity between $r_{p_1}-r_e$ and $r_{m_1}-r_{p_1}$, or between $r_{p_2}-r_{m_1}$ and $r_{m_2}-r_{p_2}$. Thus ionospheric models with a steep gradient or, on the contrary, with a very smooth gradient, might be introduced. The quantities which have been calculated are shown in Fig. 2; this figure needs no further explanation. In Tables II and III, extensive examples for an arbi-

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* Original manuscript received by the IRE, May 11, 1959.

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TABLE I

Ionospheric Models

Number	E maximum MHz	F_2 maximum MHz	hF_2 km	Number	E maximum MHz	F_2 maximum MHz	hF_2 km
1	4	14	400	13	2	8	400
2	4	14	200	14	2	8	200
3	2	14	400	15	4	6	400
4	2	14	200	16	4	6	200
5a	4	12	400	17	3	6	400
6a	4	12	200	18	3	6	200
7a	3	12	400	19	2	6	400
8a	3	12	200	20	2	6	200
9a	2	12	400	21	3	4	400
10a	2	12	200	22	3	4	200
5	4	10	400	23	2	4	400
6	4	10	200	24	2	4	200
7	3	10	400	25	2	3	400
8	3	10	200	26	2	3	200
9	2	10	400	27	1	3	400
10	2	10	200	28	1	3	200
11	4	8	400	29	1	2	400
12	4	8	200	30	1	2	200

hE maximum = 110 km.

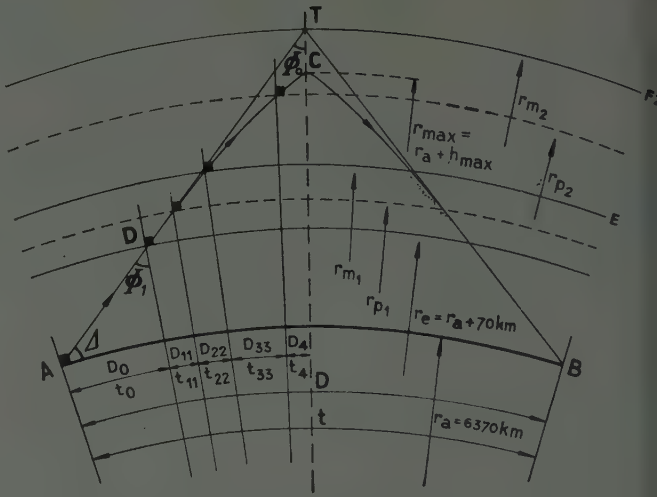


Fig. 2—Quantities calculated.

TABLE II

f=6 MHz MODEL 14 (2-8-200 km). f=6 MHz

$\Delta°$	$\Phi_1°$	h maximum	t (msec)	D km	t_0	t_1	t_{11}	t_2
6	79.646	86.329	4.20934	1238.46	1.64080	0.46387		
8	78.381	88.156	3.66350	1072.39	1.37001	0.46174		
10	76.933	90.240	3.25628	947.25	1.16755		0.41534	0.04525
12	75.357	92.870	3.00072	866.20	1.01320		0.32043	0.16673
14	73.689	96.640	2.89606	828.17	0.89302		0.27280	0.28221
16	71.956	103.496	3.15826	892.25	0.79755		0.23938	0.54220
18	70.173	116.275	3.23058	900.97	0.72032		0.21394	
20	68.354	119.536	2.83086	780.26	0.65682		0.19375	
25	63.697	125.379	2.31598	615.42	0.53938		0.15759	
30	58.939	130.095	2.01930	511.79	0.45964		0.13366	
35	54.121	134.253	1.81952	436.40	0.40270		0.11678	
40	49.264	138.005	1.67582	375.61	0.36051		0.10437	
45	44.381	141.404	1.56850	324.30	0.32846		0.09498	
50	39.480	144.467	1.48644	279.21	0.30367		0.08774	
55	34.565	147.194	1.42284	238.35	0.28431		0.08210	

f=6 MHz MODEL 14 (2-8-200 km). f=6 MH

t_{22}	t_3	$2D_0$	$2D_1$	$2D_{11}$	$2D_2$	$2D_{22}$	$2D_3$	V km/msec
		968.72	269.74					294.21
		805.13	267.26					292.72
		682.23		239.04	25.98			290.89
		587.96		183.22	95.02			288.66
		514.01		154.75	159.41			285.96
		454.76		134.54	302.95			282.51
0.41628	0.26475	406.34		118.94		229.99	145.70	278.88
0.30320	0.26166	366.08		106.45		165.54	142.19	275.62
0.20146	0.25956	289.93		83.51		106.19	135.88	265.72
0.15751	0.25884	236.08		67.68		79.27	129.36	253.44
0.13180	0.25848	195.63		55.94		62.74	122.09	239.84
0.11476	0.25827	163.78		46.75		51.08	114.00	224.13
0.10267	0.25814	137.74		39.27		42.19	105.10	206.75
0.09374	0.25807	115.75		32.98		35.02	95.46	187.83
0.08699	0.25802	96.71		27.53		28.99	85.12	167.51

TABLE III

$f=12$ MHz MODEL 14 (2-8-200 km). $f=12$ MHz

$\Delta°$	$\Phi_1°$	h maximum	t (msec)	D km	V km/msec	t_0	t_{11}	t_{22}
6	79.646	124.020	6.14	1795.00	292.34	1.64080	0.38214	0.49940
8	78.381	126.799	5.32	1549.10	291.18	1.37001	0.33892	0.41298
10	76.933	129.745	4.72	1360.50	288.24	1.16755	0.30048	0.34875
12	75.357	132.778	4.22	1213.50	287.00	1.01320	0.26779	0.30048
14	73.689	135.854	3.84	1096.30	285.49	0.89302	0.24042	0.26341
16	71.956	138.945	3.56	1001.40	281.20	0.79755	0.21756	0.23430
18	70.173	142.035	3.32	922.40	277.83	0.72032	0.19840	0.21097
20	68.354	145.111	3.12	855.94	274.70	0.65682	0.18222	0.19192
25	63.697	152.679	2.75	726.13	264.51	0.53938	0.15140	0.15699
30	58.939	160.640	2.65	642.23	252.24	0.45964	0.12898	0.13348
35	54.121	171.828	2.57	612.05	237.78	0.40270	0.11427	0.11678

$f=12$ MHz MODEL 14 (2-8-200 km.) $f=12$ MHz

t_3	t_{33}	t_4	$2D_0$	$2D_{11}$	$2D_{22}$	$2D_3$	$2D_{33}$	$2D_4$
0.5491			968.70	222.23	288.62	315.53		
0.54253			805.10	196.25	237.65	310.25		
0.73779			682.20	173.04	199.59	305.67		
0.53432			588.00	153.17	170.81	301.46		
0.53173			514.00	136.41	148.54	297.41		
0.52974			454.80	122.29	130.89	293.36		
0.52819			406.30	110.34	116.61	289.22		
0.52695			366.08	100.13	104.81	284.92		
0.52479			289.93	80.24	82.69	273.27		
	0.37343	0.17657	236.08	65.78	67.18		185.92	87.27
	0.30303	0.35021	195.63	54.73	55.59		142.75	163.35

trarily chosen model 14, and for frequencies 6 MHz and 10 MHz, respectively, are given. The results have been laid down in a set of curves that will be discussed hereafter.

The basic idea of this method is to find which ionospheric model, or which pair of ionospheric models, approaches the real ionosphere actually present at the given date and hour. For this purpose, it is necessary in the first place to have at one's disposal the ionogram for a station near to the reflection point, or the ionograms of two stations situated as near as possible to the points A and B. (For prediction purposes, the ionospheric quantities may be taken from the prediction charts.) For the chosen model 14, the quantities for distance D (one hop), traveling time t, maximum height $h_{\max}$, MUF (maximum usable frequency), etc., are formed by means of the appropriate curves.

III. ONE-HOP AND MULTI-HOP DISTANCES AND TRAVELING TIMES

In Fig. 3 the one-hop distances as function of the radiation angle $\Delta°$ are given for the model 14. It can be clearly seen that the E layer takes a certain part of the radiated energy to abnormally great "hop" distances. For instance for 8 MHz, in the radiation angle from 9° to 11°, and for 6 MHz in the interval between 16° and 18°, this phenomenon is quite evident.

Calculations for all models and frequencies of the velocity of the radius vector at the surface of the earth, *i.e.*, the mean velocity with which the radio signal travels from A to B, result in the diagram of Fig. 4, giving the velocity V as a function of $\Delta°$. The dotted line represents the velocity $V_0=2D_0/2t_0$ presuming there is no ionosphere and the ray is reflected mirror-like at the point T (see Fig. 2). The double-hatched part represents the models with F_2 maximum at 200 km, the single-hatched part gives the models with F_2 maximum at 400 km (see Table I). The lines passing from a higher to a lower curve (indicated by the frequency belonging to them) represent the transition from E-region transmission to F-region transmission. This comparatively sharp change in transmission velocity often occurs in the midst of the radiation angle, which means that a part of the energy is transported at a 1 per cent or 2 per cent lower velocity as soon as an E layer crossing takes place. It is obvious that for an effective radiation angle of 6° to 12° in Fig. 4 the frequency of 16 MHz is transmitted via the E layer for values below 8° and via the F_2 layer for values above 8°.

Long-distance oblique incidence pulse tests often show a tendency to produce at the receiving station two separate pulses varying in amplitude but showing a constant time interval for hours on end. This phenomenon might be explained by Fig. 4. Taking for

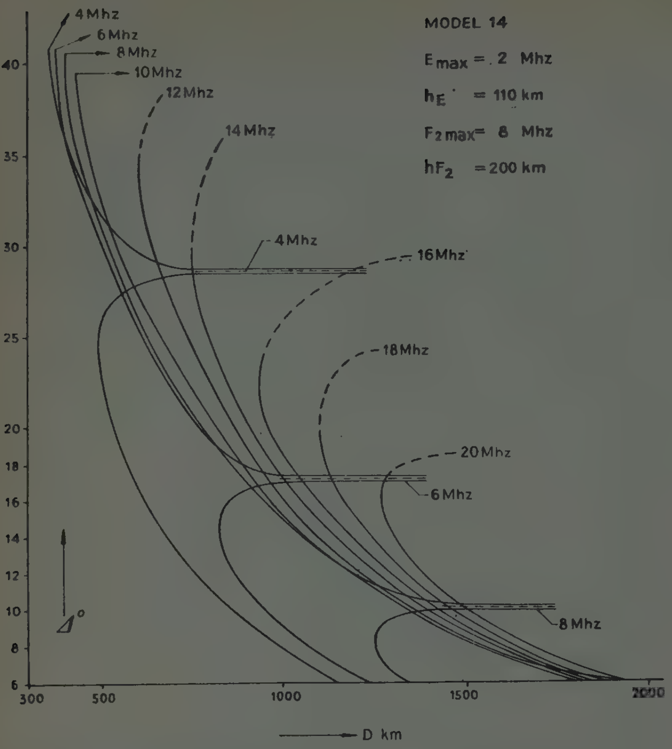


Fig. 3—One-hop distances as a function of radiation angle Δ.

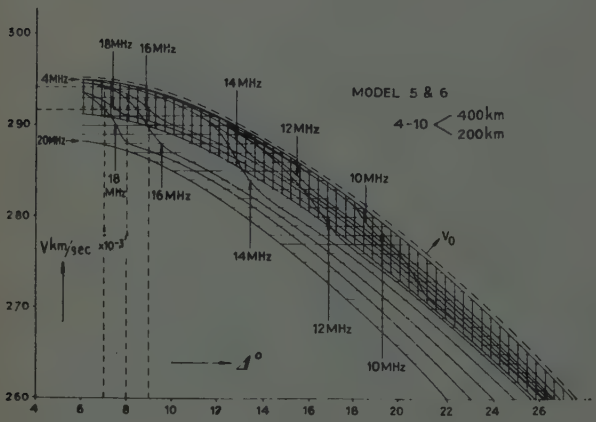


Fig. 4—Velocity curves at the earth surface.

model 6, *e.g.*, the frequency 16 MHz, the difference between horizontal velocity at the earth surface below 7° and above 9° is from 293,000 km/second to 290,000 km/second, that is, 1 per cent. For a total transmission distance of 8700 km or 30 m/second this means 0.3 m/second time interval between pulses. This result is consistent with experience.

The differences in horizontal velocity at earth surface are strikingly small. This velocity depends in the first place on the cosine of the radiation angle; the frequency and the model have no great influence. The well-known fact that echoes round the earth show an astonishing independency of frequency and of ionospheric situations [2], [4] is in accordance with the above-mentioned result.

The problem of multi-hop transmission poses the following considerations for us. After the first earth reflections the effective radiation angle is certainly widened considerably. Furthermore it would be necessary to take another model for the second hop-region in accordance with local conditions. In Section IV the MUF curves for one-hop transmission are given; for the second and third hop one has to take again the appropriate model.

In future practice the application of the model system might give a valuable basis for more exact path calculations in radio traffic.

IV. MUF Frequencies

The formulas used to find the various desired quantities for each model include also maximum real heights for oblique and for vertical incidence. Fig. 5 gives the h_2 values for model 14 as a function of $\Delta°$. The MUF may be read from Fig. 5 as follows. For $\Delta = 22°$ the MUF is found to lie between 18 and 20 MHz on the 200 km line (f_0F_2 maximum). Interpolation gives 18.6 MHz. For model 13, that differs from 14 only insofar as the F_2 layer is situated at 400 km instead of at 200 km, the MUF for $\Delta = 22°$ appears to be 17.0 MHz (see Fig. 6), a strikingly small difference. The MUF curves of Fig. 6 have been constructed with the aid of Fig. 5.

Comparing Fig. 6 with Table I, one will see that the influence of the strength of the E layer on the MUF is not very great. The influence of the radiation angle within a certain range is about 10 to 15 per cent. The groups of MUF curves in Fig. 6 belong to models 5 to 30 inclusive. To find the favorable hop distance it is obvious that a certain "bandwidth" of radiation angles has to be selected. The family of curves resulting from the study of the ionospheric models are consistent with the formulas and diagrams of Smith [5].

V. Vertical Incidence- and Oblique Incidence-Ionograms

For all models the vertical incidence (ionogram) values have been calculated, and this makes possible a comparison of the diagrams with measured ionograms (Fig. 7). The difficulty is that the number of models (up to March 1959 67 models were available) has to be increased considerably, because, *e.g.*, E layers of strength 1, 2, 3, and 4 MHz do not give sufficient choice. One ought to have the possibility to choose from the series 2; 2, 2; 2, 4; 2, 6 MHz, etc. Still, it is clear that a model can be chosen which gives a good fit to the measured ionogram. In Fig. 8 recent rocket data [8], [9] for real heights have been compared with our models 22, 5, and 17 w.

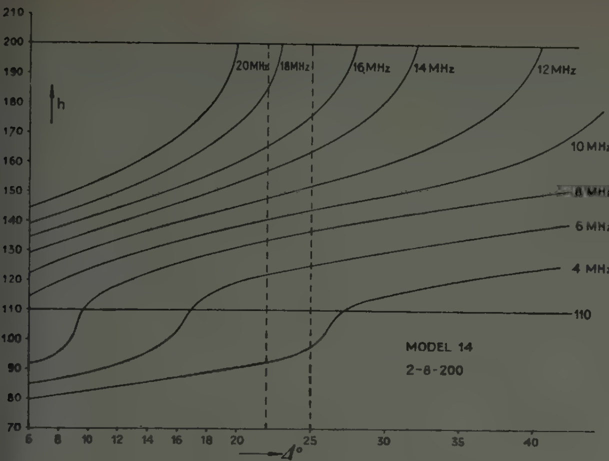
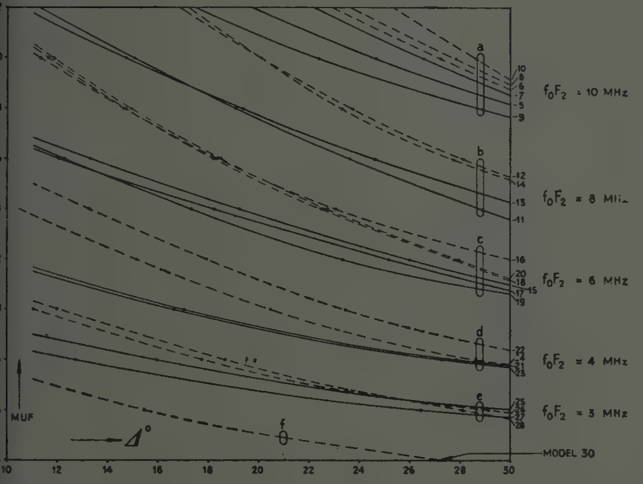


Fig. 5—Real heights as a function of frequency and radiation angle.



ig. 6—MUF curves for different models. a = models 5, 6, 7, 8, 9 and 10; b = models 11, 12, 13 and 14; c = models 15, 16, 17, 18, 19 and 20; d = models 21, 22, 23 and 24; e = models 25, 26, 27 and 28; f = model 30.

The formula giving the relation between vertical-ncidence frequency $f_\perp$ and oblique incidence frequency $\measuredangle$ for a given radiation angle and a given $h_{\max}$, [5], is

$$f\measuredangle = \frac{f_\perp}{\sqrt{1-\left(\dfrac{r_e}{r_a+h_{\max}}\sin\Phi_1\right)^2}},$$

vhich is in agreement with Fig. 5 and the dotted line real height) of model 14 in Fig. 7; this can be verified y the reader.

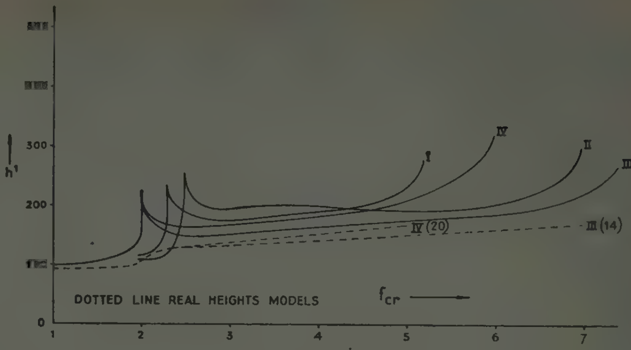


Fig. 7—Ionograms models 14 (III) and 20 (IV). Ionograms Lindau 29-12-'54-10.00 U.T. (I) and 4-1-'55-12.30 U.T. (II).

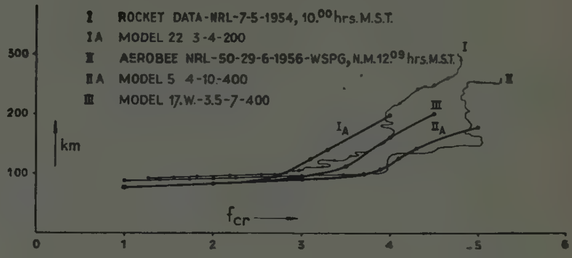


Fig. 8—Rocket data real heights compared with models.

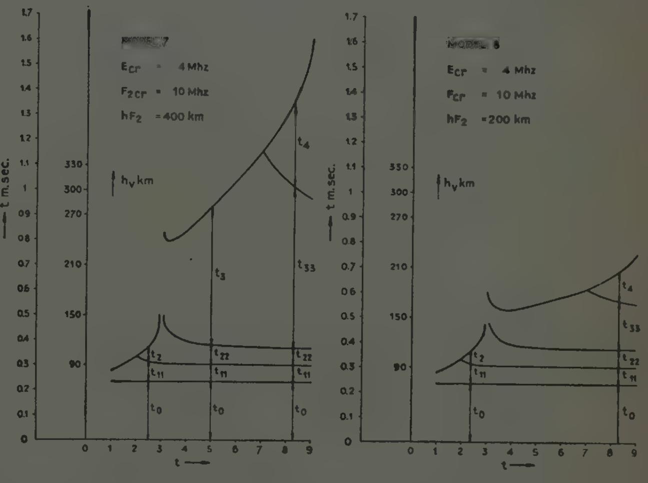


Fig. 9—Traveling time per region as a function of frequency (vertical incidence).

The vertical incidence diagram demonstrates a curi-ous fact. In Fig. 9 the traveling time as a function of the requency for vertical incidence (in fact the ionogram) s given, in total as well as for the parts 1, 2, 3, and 4 of the ionosphere; part 1 being that between r_e and r_{p_1} (see Fig. 2), part 2 between r_{p_1} and r_{m_1}, part 3 between r_{m_1} and r_{p_2}, and part 4 between r_{p_2} and the maximum height reached by the ray. The vertical distances that the ray has to travel in passing parts 1 and 2 are 20 km. For parts 3 and 4 these values are 145 km for the odd-numbered models and 45 km for the even-numbered ones (see Table I). It is evident that for a rather high frequency (on the straight part of the F_2 trace of the

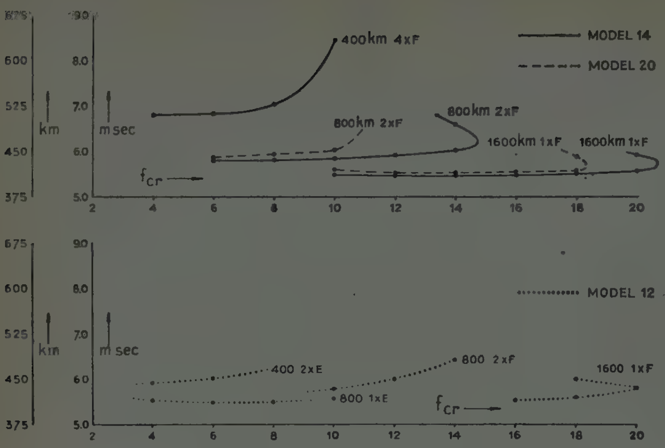


Fig. 10—Oblique incidence sweeping frequency.

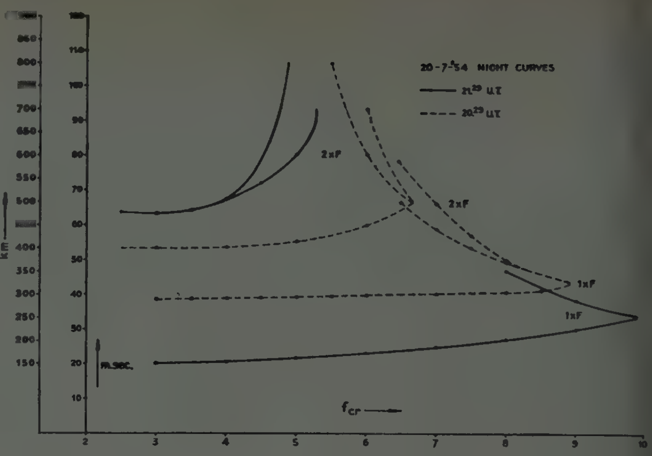


Fig. 11—Oblique incidence sweeping frequency, Lindau-Helsinki.

ionogram) the velocity with which the ray passes through the lower parts of the ionosphere approaches the light velocity. The traveling-time curves (Fig. 9) demonstrate this fact. The ionograms are drawn with a linear frequency scale and a traveling-time scale much larger than normally in use. This facilitates the analysis of the ionogram. A paper on this subject is in preparation.

Figs. 10 and 11 give oblique incidence curves for 1600 km distance for models 14, 20, and 12 as well as for the Lindau-Helsinki experiments [7]. Also, for this sort of experiment models may be found which fit the situation. It will be clear to the reader that the "horizontal" lines in Figs. 10 and 11 are a demonstration of the aforementioned fact, that the horizontal velocity is strongly independent of frequency and slightly dependent on the radiation angle (see Fig. 4).

VI. Other Methods

The fundamental problem for ionospheric propagation studies is to find the distribution of electrons in the ionosphere and to deduce this distribution from ionospheric sounding. A very good survey of this problem was given by Thomas [6].

Formulas giving the amount of electrons in a vertical cylinder up to a variable height for each ionospheric model have been published elsewhere [10]. These values, which have not yet been produced in the form of curves, can also be obtained by simple planimetry below the ionization curves of each model down to zero N.

VII. Conclusion

The method of studying ionospheric models is suggested as a way of attacking the problem of ionospheric radio propagation. The ionograms, which are available in great quantity nowadays, yield E and F critical frequencies, but the conventional methods, by which the practical values of MUF, etc., are produced, are not very accurate. The method described above might give a more sound basis for frequency-predictions.

VIII. Acknowledgment

The author is indebted to A. L. Steiner of the Mathematical Section, and the Miss E. P. M. Vermey of the Ionosphere and Radio Astronomy Section of the Netherlands Postal and Telecommunications Services for their valuable assistance, the former with the calculations, made possible by the electronic computer "Zebra," and the latter with the plotting of the curves.

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Electromagnetic Properties of High-Temperature Air*

M. P. BACHYNSKI†, T. W. JOHNSTON†, AND I. P. SHKAROFSKY†

Summary—**This paper concerns the attenuation and phase characteristics of plasmas and, in particular, the electromagnetic properties of high-temperature air. It is shown that by a suitable normalization of the parameters the electromagnetic properties of plasmas may be universally represented in convenient form in either the complex dielectric coefficient plane or the complex propagation constant plane. Next, the electron number densities and electron collision frequencies for air ranging in temperature from 3000° to 12,000°K and in density from 10^1 to 10^{-4} times the density at sea level are illustrated. The attenuation and phase constants for an electromagnetic wave traversing this medium have been evaluated for frequencies from 10^9 to 10^{11} cps. As an example, the above universal representation is applied to the stagnation region of a hypersonic vehicle in space.**

INTRODUCTION

DUE to ionization, air at high temperatures contains an appreciable number of free electrons and ions. Under these conditions, the medium may be described as a plasma, *i.e.*, a gas containing charged particles in a sufficient quantity to seriously alter the physical properties of the gas. One of the properties of air markedly affected by the presence of the electrons and ions is the propagation of electromagnetic waves in such a medium. This interaction of electromagnetic waves with plasmas is of current interest in connection with diagnostic techniques, space communications, and re-entry problems.

The following paper is concerned with the electromagnetic characteristics of plasmas and, in particular, those of high temperature air. It is shown that by a suitable normalization of parameters, these properties can be represented in a convenient, universal form in either the complex dielectric coefficient plane or the complex propagation constant plane. Values of the electron density and electron collision frequency are shown for air in the temperature range 3000° to 12,000° K, and densities ranging from 10^1 to 10^{-4} times the density at sea level. Further, the attenuation and phase constants of electromagnetic wave propagating in a medium of air at high temperatures are evaluated for radio frequencies ranging from 10^9 to 10^{11} cps.

Finally, as an example, the variation of attenuation and phase of an electromagnetic wave with altitude and velocity is determined for the stagnation region of a hypersonic vehicle.

ELECTROMAGNETIC PARAMETERS OF A UNIFORM PLASMA[1]

Dielectric Coefficient

The dielectric coefficient of an infinite uniform plasma, *i.e.*, a plasma where electron density is not a function of position in the absence of an electromagnetic field, can be deduced from Maxwell's fourth equation. Thus, assuming a harmonic field variation $\epsilon^{j\omega t}$ and the permittivity of the plasma to be the same as free space permittivity ϵ_0, one can write, using rationalized mks units,

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial}{\partial t}(\epsilon_0 \vec{E}) \tag{1a}$$

$$= \sigma\vec{E} + j\omega\epsilon_0\vec{E} \tag{1b}$$

$$= j\omega\epsilon_0 K\vec{E}, \tag{1c}$$

where

$\vec{H}$ and $\vec{E}$ are the magnetic and electric fields respectively of an impressed electromagnetic wave incident on the plasma,
J is the ac current density,
$\epsilon_0 E$ represents the electric displacement,
σ is the ac electronic conductivity of the plasma,
ω is the radian frequency of the electromagnetic wave,
$j = \sqrt{-1}$, and
K is the effective dielectric coefficient given by

$$K = 1 + \frac{\sigma}{j\omega\epsilon_0}\cdot \tag{2}$$

In the absence of a dc magnetic field, the electronic conductivity σ of a plasma to an RF signal of frequency ω is given by[2,3]

$$\sigma = -\frac{4\pi}{3}\frac{e^2}{m}\int_0^\infty \frac{1}{\nu + j\omega}\frac{\partial f_0^0}{\partial v}v^3 dv \tag{3a}$$

where

e and m are the electronic charge and mass respectively,
f_0^0 is the electron velocity distribution function,

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* Original manuscript received by the IRE, August 5, 1959. This paper was presented at the URSI International Symposium on Electromagnetic Theory, Toronto, Can., June 15–20, 1959.

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[1] This section is intended only as a summary to define the various parameters.

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v is the electron velocity, and
ν is the effective collision frequency of the electrons (equal to the reciprocal of the time between successive collisions).

If the collision frequency is independent of electron velocity, (3a) simplifies to

$$\sigma = \frac{ne^2}{m(\nu + j\omega)} \tag{3b}$$

where n is the number density of electrons, which is a reasonable approximation for air at temperatures considered here (particularly 6000°K–12,000°K).

Using (3b) in (2), the dielectric coefficient becomes

$$K = \left\{1 - (\omega_p/\omega)^2 \frac{1}{1 + (\nu/\omega)^2}\right\} - j\left\{(\omega_p/\omega)^2 \frac{(\nu/\omega)}{1 + (\nu/\omega)^2}\right\} \tag{4a}$$

$$= Kr + jKi \tag{4b}$$

where the parameter $ne^2/\epsilon_0 m = \omega_p^2$ has the dimensions of seconds^{-2} and ω_p is the "plasma frequency." Kr and Ki are the real and imaginary parts, respectively, of the dielectric coefficient.

Propagation Constants

In a uniform plasma it is assumed that the electron density in the absence of a field is not a function of position and in a neutral plasma there is no net charge, so that the charge density is zero. Hence, the electric field in the plasma is divergenceless, *i.e.* $\nabla \cdot \boldsymbol{E} = 0$. Further, by the usual manipulation of Maxwell's third and fourth equations the Helmholz vector equations for $\boldsymbol{E}$ and $\boldsymbol{H}$ are obtained. Thus

$$\nabla^2 \boldsymbol{E} + k^2 K \boldsymbol{E} = 0$$
$$\nabla^2 \boldsymbol{H} + k^2 K \boldsymbol{H} = 0, \tag{5a}$$

where

$k = \omega/c = 2\pi/\lambda$,
c = velocity of light,
λ = free-space wavelength.

It is seen that both $\boldsymbol{E}$ and $\boldsymbol{H}$ satisfy the same vector equation. For any specific problem, solving either, subject to the proper boundary conditions, will give the complete solution.

The solutions of (5a) for a plane wave propagating through a uniform plasma are given in rectangular coordinates by

$$E_x = E_0 \epsilon^{j\omega t} \epsilon^{-\gamma z}, \qquad E_y = E_z = 0;$$
$$H_y = H_0 \epsilon^{j\omega t} \epsilon^{-\gamma z}, \qquad H_x = H_z = 0; \tag{5b}$$

where γ, the propagation constant, is defined by

$$\gamma = jkK^{1/2}. \tag{6a}$$

γ is complex, and of the two solutions for γ which differ in sign, the solution yielding a negative real part in the exponent is chosen in order to insure attenuation as the wave propagates. Thus

$$\gamma = \alpha + j\beta, \tag{6b}$$

where

$$\frac{\alpha}{k} = \sqrt{\frac{|K| - Kr}{2}} = A, \tag{6c}$$

$$\frac{\beta}{k} = +\sqrt{\frac{|K| + Kr}{2}} = B, \tag{6d}$$

$$|K| = (Kr^2 + Ki^2)^{1/2}, \tag{6e}$$

and α is called the attenuation constant, β the phase constant, of the plasma.

It is seen that the propagation constants of a plasma are determined by the effective dielectric coefficient which in turn depends on the electron density and collision frequency.

UNIVERSAL REPRESENTATION OF ELECTROMAGNETIC PARAMETERS FOR CONSTANT COLLISION FREQUENCY

It is instructive to rewrite the relationships determining the complex dielectric coefficient and propagation constant in normalized form, and hence to demonstrate their behaviour in universal coordinates. Thus, define the following parameters

1) Normalizing with respect to frequency:
   $S = \nu/\omega$ = normalized scattering frequency,
   $N = (\omega_p/\omega)^2$ = normalized electron density.
2) Normalizing with respect to plasma frequency (*i.e.* $n^{1/2}$):
   $C = \nu/\omega_p$ = normalized collision parameter,
   $F = \omega/\omega_p$ = normalized RF frequency.

These relationships permit the mapping of loci of constant scattering frequency S, constant electron density N, constant collision parameter C, or constant RF frequency F on the complex dielectric coefficient plane and on the complex propagation constant plane. S and N are the useful parameters to consider in a diagnostic measurement, with a given frequency and varying plasma, while C and F are useful when the frequency behavior of a given plasma is of interest.

Dielectric Plane

Using (4a) for the complex dielectric coefficient, it is easily shown that the normalized scattering term is given by

$$S = Ki/(Kr - 1), \text{ or} \tag{7a}$$

$$(Kr - 1)S + Ki = 0, \tag{7b}$$

which is a family of straight lines in the complex dielectric (Kr vs Ki) plane, with slope $-S$ and Kr-intercept of 1.

Similarly, the normalized electron density is

$$N = 1 - Kr + Ki^2/(1 - Kr), \text{ or} \tag{8a}$$

$$(Kr - (1 - N/2))^2 + Ki^2 = (N/2)^2, \tag{8b}$$

which in the complex plane is a family of circles of radius $N/2$ and center $(Kr = (1 - N/2),\ Ki = 0)$.

Representation in terms of the normalized collision parameter is slightly more difficult in that

$$C^2 = S^2/N, \tag{9a}$$

or in terms of the real and imaginary part of the dielectric coefficient,

$$(1 - Kr)^3 + Ki^2(1 - Kr) - Ki^2/C^2 = 0 \tag{9b}$$

or

$$Ki = (1 - Kr)\left(\frac{1}{C^2(1 - Kr)} - 1\right)^{-1/2}, \tag{9c}$$

with a pole at $Kr = 1 - 1/C^2$.

The normalized RF frequency loci are again circles in the complex dielectric coefficient plane since

$$F = 1/\sqrt{N} \tag{10}$$

The radius of the F-circles is $1/2F^2$ and their centers are located at $[Kr = (1 - 1/(2F^2)),\ Ki = 0]$.

Families of constant scattering frequency and constant electron density normalized to signal frequency plotted in the dielectric plane are shown in Fig. 1(a), while contours of constant collision parameter and RF frequency normalized to the plasma frequency are shown in Fig. 1(b).

Propagation Plane

Representation of the normalized parameters in the complex propagation constant plane can be derived from a conformal transformation of values in the dielectric plane, since from (6a), (6c) and (6d),

$$A + jB = jK^{1/2}, \tag{11}$$

or from a direct solution for the normalized parameters in terms of the attenuation and phase constants. Since the maximum value of the real part of the dielectric constant is unity, the upper limit in the propagation plane is given by the line $Kr = 1$ which maps into the hyperbola $B^2 - A^2 = 1$.

The normalized scattering frequency loci become rectangular hyperbolas rotated through an angle of $1/2\ \tan^{-1}(1/S)$ in the complex propagation constant plane, namely

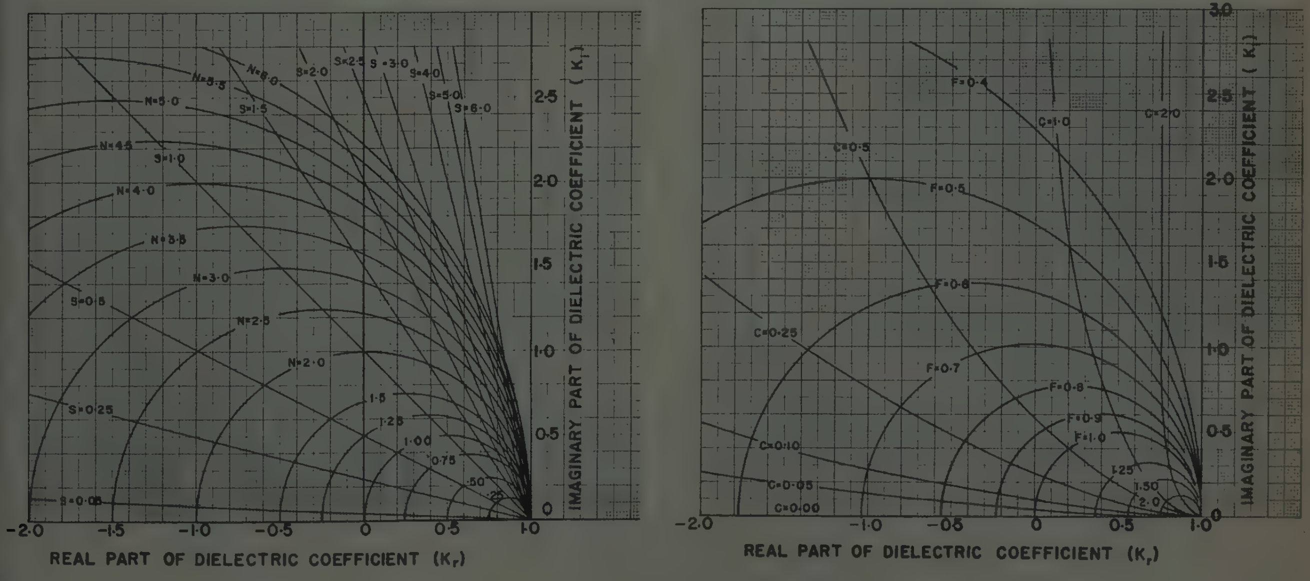
$$S = \frac{2AB}{1 - (B^2 - A^2)}, \text{ or} \tag{12a}$$

$$B^2 - A^2 + 2AB/S = 1. \tag{12b}$$

The normalized electron density families become quartic curves since

$$N = 1 + A^2 - B^2 + 4A^2B^2/(1 + A^2 - B^2), \text{ or} \tag{13a}$$

$$(A^2 + B^2)^2 - (2 - N)(B^2 - A^2) + (1 - N) = 0. \tag{13b}$$



(a) (b)

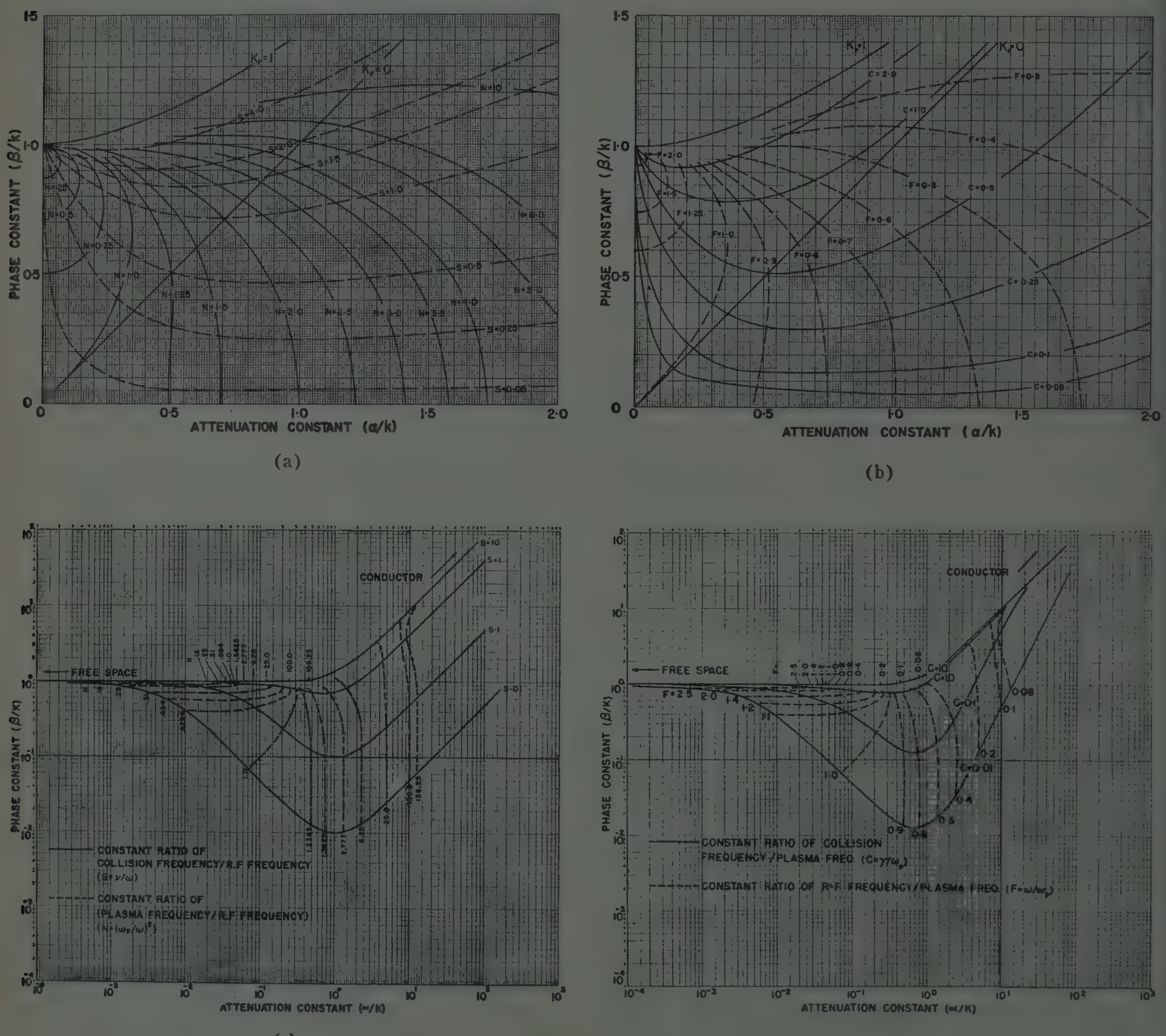
Fig. 1—(a) Variation of normalized scattering frequency (S) and normalized electron density (N) in the complex dielectric coefficient plane. ($S = \nu/\omega$; $N = (\omega_p/\omega)^2$.) (ν = electron collision frequency, ω = RF frequency, ω_p = plasma frequency.) (b) Variation of normalized collision parameter C and normalized RF frequency (F) in the complex dielectric coefficient plane. ($C = \nu/\omega_p$; $F = \omega/\omega_p$.)

The normalized collision parameter C can be expressed in terms of A and B by the use of (12a) and (13a) in (9a). Similarly, the values of normalized frequency F in the propagation plane is obtained by substituting (13a) into (10).

Contours of constants S and N in the complex propagation constant plane are shown in Fig. 2(a), and plots of constants C and F in Fig. 2(b). Extended values of these parameters are shown plotted on a logarithmic scale in Figs. 2(c) and 2(d).

It will be observed that the normalized parameters map more readily into the complex dielectric coefficient plane than into the propagation constant plane. However, in measurement or diagnostics it is the attenuation and phase constants which are actually determined. Hence, the added difficulty in plotting the normalized contours in the propagation constant plane is generally justified.

A second reason for representing the plasma parameters in the propagation plane is that the reflecting or transmitting properties of a plasma boundary are very conveniently mapped in the propagation plane. Thus, if Z is the impedance of the plasma and Z_0 the impedance of free space, the fraction of the field of a normally inci-



(a)

(b)

(c)

(d)

Fig. 2—(a) Variation of normalized scattering frequency (S) and normalized electron density (N) in complex propagation constant plane. ($S=\nu/\omega$; $N=(\omega_p/\omega)^2$.) (ν = electron collision frequency; ω = RF frequency, ω_p = plasma frequency.) (b) Variation of normalized collision parameter (C) and normalized RF frequency (F) in complex propagation constant plane. ($C=\nu/\omega_p$; $F=\omega/\omega_p$.) (c) Variation of normalized scattering frequency (S) and normalized electron density (N) in complex propagation constant plane for extended values of the parameters (logarithmic scale). ($S=\nu/\omega$; $N=(\omega_p/\omega)^2$.) (d) Variation of normalized collision parameter (C) and normalized RF frequency (F) in complex propagation constant plane for extended values of the parameters (logarithmic scale). ($C=\nu/\omega_p$; $F=\omega/\omega_p$.)

dent electromagnetic wave reflected at a plasma-free space interface is given by the reflection coefficient R where from (6)

$$R = \frac{Z - Z_0}{Z + Z_0} = \frac{1 - K^{1/2}}{1 + K^{1/2}} \tag{14}$$

$$= \frac{(1 - B) + jA}{(1 + B) - jA}. \tag{14a}$$

The magnitude of the reflection coefficient is given by

$$|R| = \sqrt{\frac{1 + A^2 + B^2 - 2B}{1 + A^2 + B^2 + 2B}} \tag{15a}$$

$$= \sqrt{\frac{1 - x}{1 + x}}, \tag{15b}$$

where

$$x = 2B/(1 + A^2 + B^2). \tag{15c}$$

Similarly, the magnitude of the transmission coefficient is

$$|T| = \sqrt{1 - |R|^2} = \sqrt{\frac{2x}{1 + x}}. \tag{15d}$$

For any magnitude of reflection coefficient, the relationship between the attenuation A and the phase B is uniquely determined by (15c), which can be rewritten

$$A^2 + (B - 1/x)^2 = \left(\frac{1}{x^2} - 1\right), \qquad (15d)$$

which is a family of circles with center ($A = 0$, $B = 1/x$) and radius $[(1 - x^2)/x^2]^{1/2}$.

Families of constant reflection coefficient plotted in the propagation plane are shown in Fig. 3. If in a particular application the maximum allowable attenuation and reflection coefficient are known, then the "operating region" in the propagation plane is defined by the area enclosed by the B-axis and the lines $B^2 - A^2 = 1$, $R = R_{\max}$, and $\alpha/k = \alpha_{\max}/k$. Similar plots and operating regions may be determined for the transmission properties $T_{\min} = \sqrt{1 - |R_{\max}|^2}$ of a plasma.

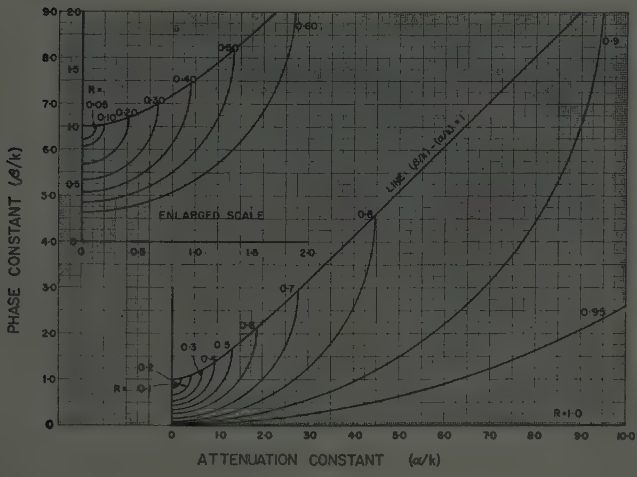


Fig. 3—Reflection coefficient (R) of an electromagnetic wave normally incident on a plasma-free space interface as represented in the propagation constant plane.

ELECTROMAGNETIC PROPERTIES OF HIGH TEMPERATURE AIR

Electron Density and Collision Frequency

At chemical equilibrium, the temperature of a hot gas has reached a stable value so that all the constituents within the plasma have been brought to this equilibrium temperature. The molar fraction of these constituents, as well as all other thermodynamic quantities, can be calculated by the methods of quantum statistical thermodynamics[4,5] which determine the partition of the energy states of a particle species into translational, rotational, vibrational, and electronic energies as well as the energies of dissociation and ionization. Tables are available giving the equilibrium quantities for air.

The electron concentration in high temperature air in thermal equilibrium as a function of temperature and density as determined by Gilmore[6] is shown in Fig. 4. At temperatures above 3000°K a rapid increase in the number of electrons occurs with rise in temperature as ionization takes place. This rate of increase gradually levels off at the higher temperatures as all the constituents become singly ionized and the number of electrons does not increase substantially with temperature.

The collision frequency of the electrons in a high temperature gas mixture such as air is generally calculated by adding the Maxwell-averaged collision cross section (weighted according to the number density of each species) of the neutral molecules to a corresponding equivalent cross section of the ions, the electron-ion collision cross section being calculated according to Spitzers[7] theory for fully ionized gases.[8,9] This method was thought to be a better approximation than the mean-free-time (constant γ) method and was used for

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[4] J. G. Logan, Jr., "The Calculation of the Thermodynamic Properties of Air at High Temperatures," Cornell Aeronautical Lab., Inc., Ithaca, N. Y., Rept. No. AD-1052-A.1; May, 1956.

[5] M. P. Bachynski, I. P. Shkarofsky, and T. W. Johnston, "Plasma Physics of Shock Fronts," Res. Labs., RCA Victor Co., Ltd., Montreal, Can. RCA Res. Rept. No. 7-801-3; June, 1959.

[6] F. R. Gilmore, "Equilibrium Composition and Thermodynamic Properties of Air to 24,000°K," RAND Corp., Santa Monica, Calif., Rept. No. RM-1543; 1955.

[7] L. Spitzer and R. Harm, "Transport phenomena in a completely ionized gas," *Phys. Rev.*, vol. 89, pp. 977–81; 1953.

[8] L. Lamb and S. C. Lin, "Electrical conductivity of thermally ionized air produced in a shock tube," *J. Appl. Phys.*, vol. 28, pp. 754–759; July, 1957.

[9] M. P. Bachynski, I. P. Shkarofsky, and T. W. Johnston, "Plasmas and the Electromagnetic Field," Res. Labs., RCA Victor Co., Ltd., Montreal, Can., RCA Res .Rept. No. 7-801-2; November, 1958.

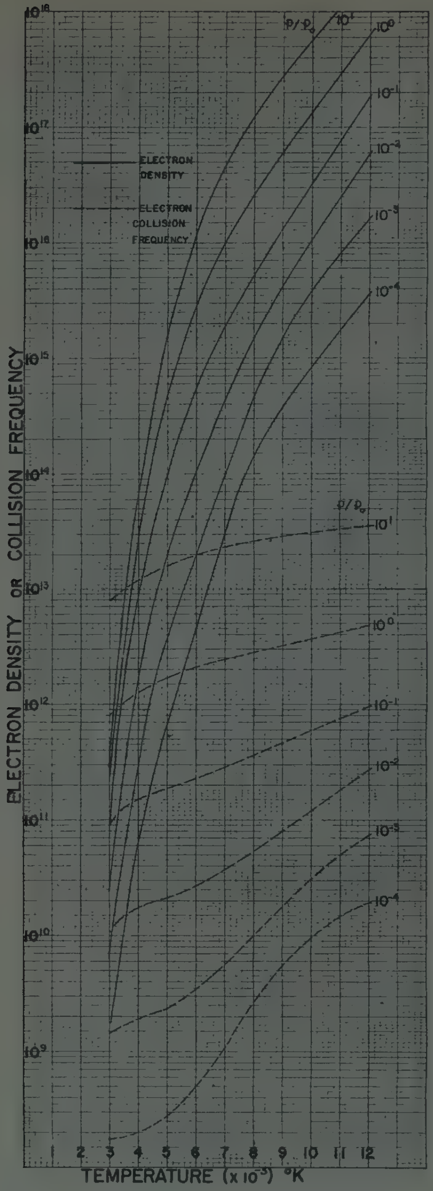

Fig. 4—Variation of electron density (n) and electron collision frequency (ν) with temperature for air at different densities. ($\rho_0=1.28823\times10^{-3}$ g/cm^3.)

this paper. The method is outlined below. Recent, more rigorous work[10] indicates that in the range 6000°K to 12,000°K, the total collision frequency is nearly a constant with velocity, so that (36) can be used but the values are slightly different from Fig. 4.

The method of constant mean free path[11] which assumes the mean free path of the electrons to be independent of electron velocity is used here to calculate the collision frequency. Making this assumption, the collision frequency for a Maxwellian distribution of electron velocities at high RF frequencies becomes[5]

$$\nu = \bar{c}\sum n_jQ_j, \tag{16a}$$

where

n_j = number density of the jth specie,
Q_j = Maxwell-averaged total electron collision cross section of the specie,

$$\bar{c}=\tfrac{4}{3}\text{ times mean electron velocity}=\frac{4}{3}\sqrt{\frac{8\kappa T}{\pi m}}, \tag{16b}$$

κ = Boltzmann's constant,
T = temperature (°K).

With the collision cross sections of the neutral species as given by Massey and Burhop[12] and calculating the conductivity due to electron-ion collisions[7,8] from

$$\sigma_{\text{ion}} = \frac{1.1632m}{\ln{(h/b_0)}}\left(\frac{4\pi\epsilon_0}{e}\right)^2\left(\frac{2kT}{\pi m}\right)^{3/2}$$

where

$$h = \left(\frac{\kappa T4\pi\epsilon_0}{8\pi ne^2}\right)^{1/2}; \qquad b_0 = \frac{e^2}{(4\pi\epsilon_0)(3\kappa T)}.$$

The variation of collision frequency with temperature and density have been evaluated using (16a). These are shown in Fig. 4 for temperatures ranging from 3000° to 12,000°K and densities from 10^1 to 10^{-4} times standard density. Although the collision cross sections of the neutral species may not be accurate, the values fall within the spread of estimates which can be obtained from the current literature. Further, at the higher temperatures the positive ion effects predominate and the influence of the neutral species becomes of lesser and lesser importance. The above plots are thus indicative of the expected variation and more accurate computation must await further experimental determination of scattering cross sections and further refinements in theory.[10]

Attenuation and Phase Constants

From the values of the electron density and collision frequency shown in Fig. 4, the attenuation and phase constants of an electromagnetic wave propagating in the plasma created by air at high temperatures can be determined by using (4a), (4b), (6c), (6d), and (6e).

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[10] I. P. Shkarofsky, M. P. Bachynski, and T. W. Johnston, "Collision Frequency Associated with High Temperature Air and Scattering Cross-Sections of the Constituents," presented at AFCRC Symposium on the Plasma Sheath, Boston, Mass.; December 7–9, 1959.

[11] L. G. H. Huxley, "Free path formulas for the electronic conductivity of a weakly ionized gas in the presence of a uniform and constant magnetic field and a sinusoidal electric field," *Aus. J. Phys.*, vol. 10, pp. 240–245; 1957.

[12] H. S. W. Massey and E. H. S. Burhop, "Electronic and Ionic Phenomena," Oxford University Press, New York, N.Y.; 1952.

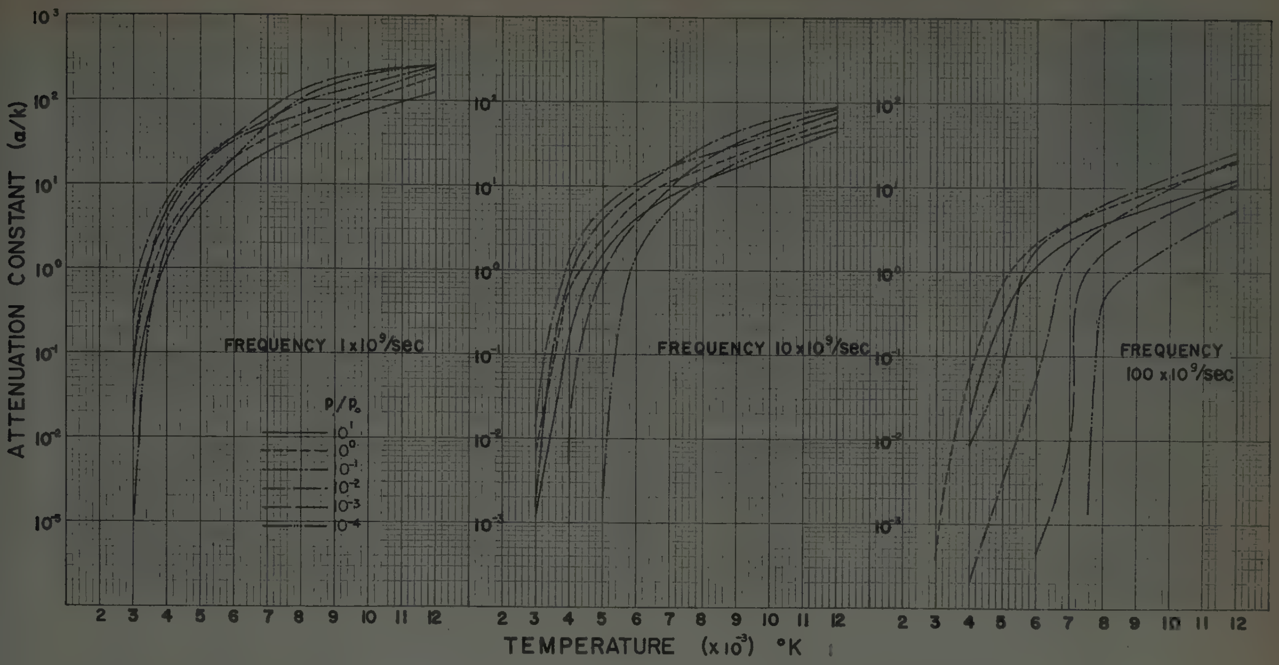

Fig. 5—Dependence of attenuation constant (α/k) on temperature and density of air. ($\rho_0=1.28823\times10^{-3}$g/cm^3.)

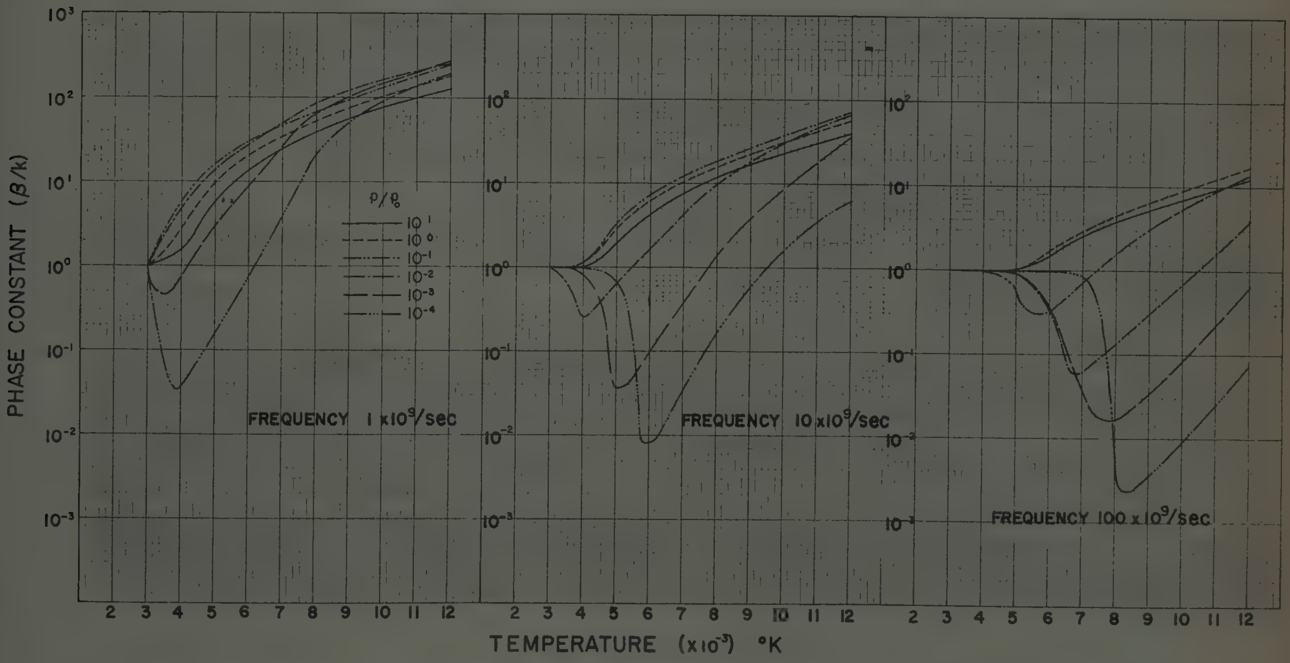

Fig. 6—Dependence of phase constant (β/k) on temperature and density of air. ($\rho_0=1.28823\times10^{-3}$g/cm^3.)

The normalized attenuation and phase constants for air in thermal equilibrium are shown as a function of temperature and density for RF frequencies of 1, 10, and 100 kmc in Figs. 5 and 6, respectively. The attenuation constant α/k increases with increasing temperature as the number of electrons and collisions become greater. Values of α/k decrease with increasing RF frequency; however, this does not mean that the attenuation necessarily decreases, since k is increasing with increasing frequency. The phase constant β/k starts off from its free-space value of unity at low temperatures, and for low densities at first decreases with increasing temperature and then increases with temperature passing through a minimum in the region where $\omega_p^2\sim\omega^2$.

For high densities, the collision terms (*i.e.,* imaginary part of the dielectric constant) predominate and no pronounced minimum values occur.

The frequency dependence of the normalized attenuation and phase constants are illustrated in Figs. 7 and 8. At a temperature of 3000°K, air is not sufficiently ionized to appreciably affect the propagation characteristics of an electromagnetic wave except for low frequencies. (The present discussion is confined to frequencies above 1 kmc, although similar analyses can be applied to the lower frequencies using the methods and data presented earlier.) At a temperature of 3000°K, air acts like a slightly lossy dielectric whose dielectric constant is nearly unity. Consequently, the phase constant is essentially the same as for free-space propagation and the attenuation constant is very small. Air in thermal equilibrium at a temperature of 6000°K can act as either a dielectric or a conductor, depending on the density and RF frequency. At low densities and high RF frequencies, air is essentially a dielectric with $\beta/k \sim 1$, and α/k is small. However, as the RF frequency is decreased, a rapid rise in attenuation and change in phase constant occurs as the plasma frequency becomes comparable to or greater than the frequency of the impressed electromagnetic wave. At high densities of air, the attenuation and phase constants are in general quite large, and decrease with increasing RF frequency. At 12,000°K, air is essentially a good conductor, exhibiting very high attenuation and phase characteristics.

The propagation characteristics of high temperature air are represented in the propagation plane for an impressed frequency of 6 kmc in Fig. 9. Contours of constant temperature, constant density, and constant reflection coefficient are shown. At low temperatures, the

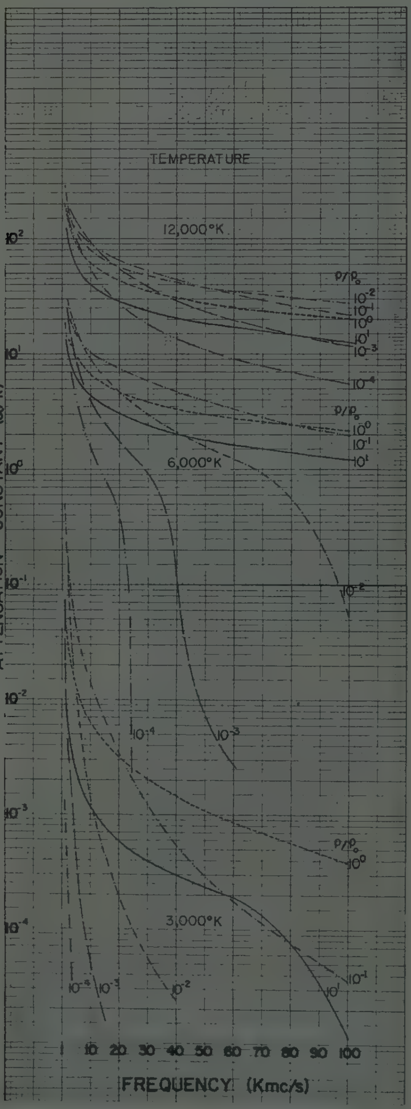

Fig. 7—Dependence of attenuation constant (α/k) on frequency for high-temperature air. ($\rho_0 = 1.28823 \times 10^{-3}$g/cm³.)

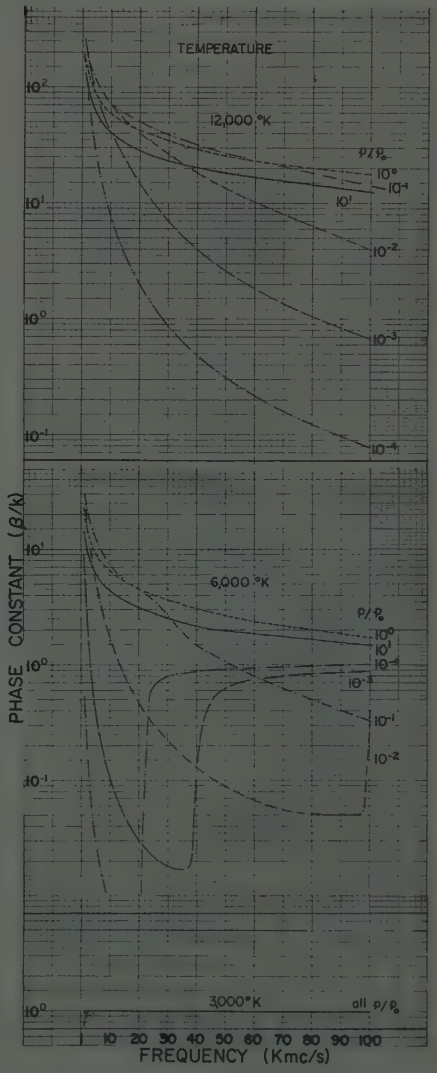

Fig. 8—Dependence of phase constant (β/k) on frequency for high-temperature air. ($\rho_0 = 1.28823 \times 10^{-3}$g/cm³.)

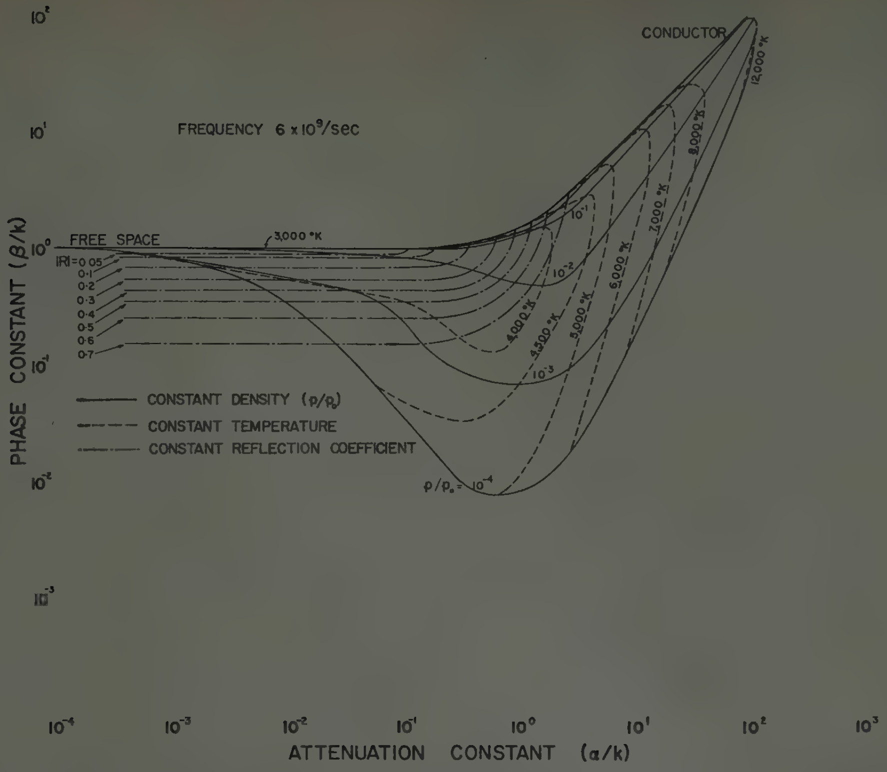

Fig. 9—Electromagnetic properties of high-temperature air at frequency of 6×10^9 cps, showing the variation of the attenuation and phase constants at constant temperature, constant density, and constant reflection coefficient.

plasma behaves nearly like free space at all densities. As the temperature increases, the influence of the ambient density becomes more apparent as the plasma becomes more lossy. At high temperatures, the plasma is a good conducting medium and the effect of density variation again becomes secondary. In this representation, an "operating region" for propagation of electromagnetic energy can be determined, provided the tolerable attenuation and reflection coefficients are specified.

HYPERSONIC VEHICLE IN PLANETARY ATMOSPHERE

A space vehicle moving at hypersonic velocities within a planetary atmosphere will be surrounded by a shock-induced ionized sheath. If the temperature and density of a given region of the shock is known, then the results presented earlier (Figs. 4–8) can be used to obtain an estimate of the propagation characteristics of an electromagnetic wave through this region. For purposes of communicating to and from a space vehicle, it is most feasible to attempt to propagate electromagnetic energy through the wake of the shock or at some point aft of the stagnation region of the shock where the influence of the plasma on an electromagnetic wave is not as pronounced as in the stagnation region; *i.e.*, the electron density and collision effects are less. However, one difficulty is that the temperature and density distribution of the shock away from the stagnation region is not very well known. On the other hand, it may be instructive to determine the propagation characteristics of an electromagnetic wave in the stagnation region of a hypersonic vehicle for two reasons, firstly that assuming thermal equilibrium the thermodynamic quantities in this region can be readily deduced from aerodynamic considerations, and, secondly, that this is the region of most dense plasma and hence the most critical conditions for penetration by, or propagation of, an electromagnetic wave.

Fig. 10 shows the variation of plasma frequency and electron collision frequency at the stagnation point of a hypersonic vehicle with velocity at various altitudes above the earth. (The ARDC model of the atmosphere was used in the aerodynamic considerations.[13]) Using the values in Fig. 10, contours of constant velocity and constant altitude for a hypersonic body have been plotted in the normalized propagation plane for frequencies of 3 kmc and 30 kmc. These are shown in Fig. 11.

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[13] A. R. Hochstim and R. J. Arave, "Various Thermodynamic Properties of Air," Convair, San Diego, Calif., Rept. No. ZPH-004; June, 1957.

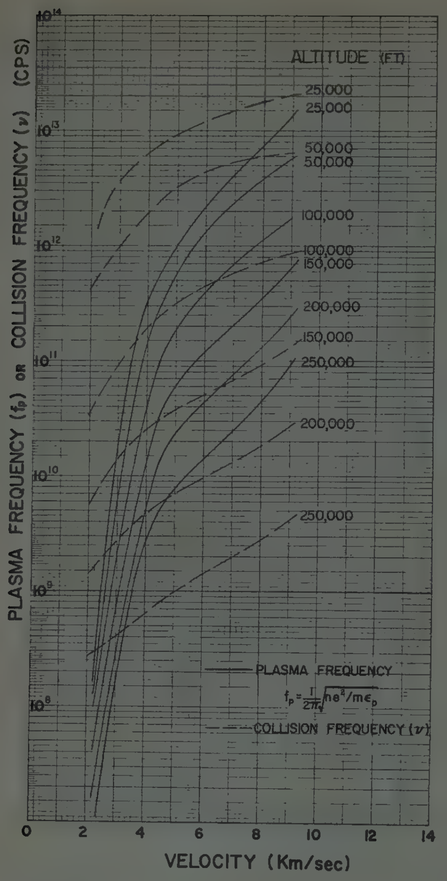

Fig. 10—Variation of plasma frequency ($f_p = 1/2\pi\ \sqrt{ne^2/m\epsilon_0}$) and electron collision frequency ν at the stagnation point of a hypersonic vehicle with velocity at various altitudes above the earth.

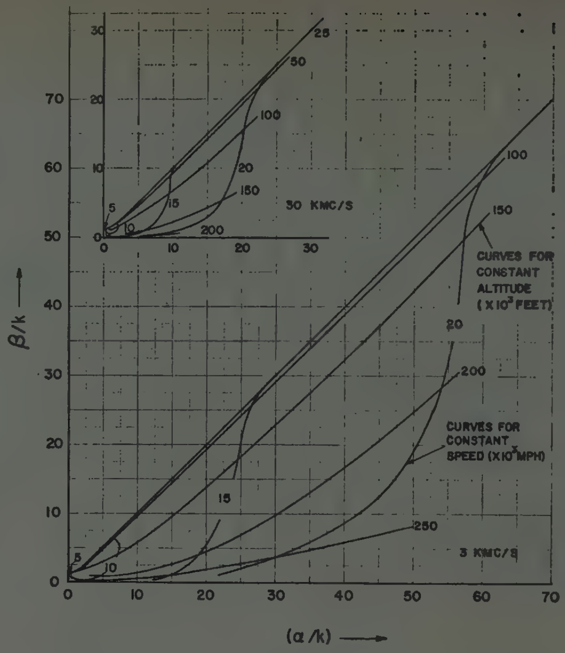

Fig. 11—Electromagnetic properties of air at the stagnation point of a hypersonic vehicle in the atmosphere at frequencies of 3×10^9 and 30×10^9 cps, showing the variation of the attenuation and phase constants with altitude and velocity.

ACKNOWLEDGMENT

The authors are indebted to the Aerophysics Wing of the Canadian Armament Research and Development Establishment for financial support.

Correspondence

Tunnel (Esaki) Diode Amplifiers with Unusually Large Bandwidths*

The bandwidth of an amplifier whose essential element is a frequency-invariant negative conductance in shunt with a parasitic capacitance, for example the tunnel (Esaki) diode,[1] is limited and tends to decrease with increasing gain. In particular, if the parasitic capacitance is resonated in a single-tuned circuit, the product of the square root of transducer-power gain and bandwidth is almost constant at high gain. Recently it was shown that for the degenerate parametric amplifier, another form of negative-conductance amplifier, maximally-flat filter circuits can be used instead of a single-tuned circuit in order to greatly increase the bandwidth.[2] The invariant gain-bandwidth product then becomes (power gain)$^{1/2n}$ times bandwidth, where n is the number of poles in the filter. The general analysis of Seidel and Herrmann[2] has been extended; a summary of this analysis, together with corroborating experimental data is presented here for three connections of negative-conductance amplifiers operated with lumped-constant filters that give an over-all maximally-flat response. A complete account of this analysis will be published at a later date.

One connection, denoted reflection type (see Figs. 1 and 2), has the generator and load located at one port of the filter, and the negative conductance at the other port. Filter-element values for a ladder structure can be chosen to give a maximally-flat (but nonminimum phase) response. Design equations for the cases of $n=2$ and $n=3$ are given in Fig. 3. Note that the element values are functions of the prescribed gain. Fig. 4 shows the very large increases in bandwidth predicted for this connection, compared with those obtained using single-tuned circuits, particularly at high gain. Note that, at a given gain, the principal relative increase in bandwidth is in going from $n=1$ to $n=2$. The $n=3$ filter does have the advantage, however, of permitting parasitic shunt capacitance in the load circuit to be incorporated in the filter.

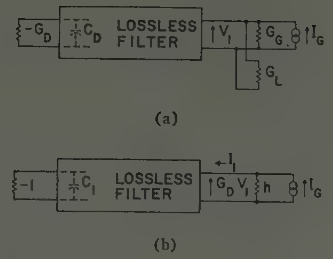

Fig. 1—Low-pass reflection-type maximally-flat negative-conductance amplifier. For band pass, insert a capacitance in series with each series inductance and an inductance in shunt with each shunt capacitance, each pair resonating at the center frequency. (a) Low-pass circuit; (b) normalized low-pass circuit.

$$h = \frac{G_G + G_L}{G_D} > 1 \qquad g_G = \frac{G_G}{G_L}$$

$$C_1 = \frac{C_D}{G_D} \qquad Z = \frac{G_D V_1}{I_1}$$

$$\text{POWER GAIN, } K = \rho h^2 \left|\frac{Z}{1+hZ}\right|^2, \quad \rho = \frac{4g_G}{(1+g_G)^2}$$

$$K_0 = \frac{\rho h^2}{(h-1)^2} \text{ OR } h = \frac{1}{1-\sqrt{\dfrac{\rho}{K_0}}}$$

Fig. 2—Basic equations for Fig. 1. The parameters of the normalized Fig. 1(b) are related to those of Fig. 1(a). Note that the parasitic capacitance of the negative conductance is incorporated in the filter.

Another connection is the reflection type operated with a circulator to isolate the generator and load. This is the configuration previously described,[2] and it has the usual advantages of operating a negative conductance amplifier with a circulator—that is, greater bandwidths for the same gain and greater gain stability against changes in generator and load values. The response is similar to that for operation without a circulator; and design equations can be related to those in Figs. 2 and 3 as follows The new value of h is

$$h' = \frac{G_0}{G_D} > 1 \tag{1}$$

where G_0 is the characteristic conductance of the circulator. The new values of power gain are

$$K' = \left|\frac{h'Z-1}{h'Z+1}\right|^2 \tag{2a}$$

$$K_0' = \left(\frac{h'+1}{h'-1}\right)^2, \text{ or } h' = \frac{\sqrt{K_0'}+1}{\sqrt{K_0'}-1}. \tag{2b}$$

The parameter h in the equations for α and β is replaced by the quantity $[1+(h')^2]/2$; or, alternatively, these equations hold for a new gain, $K_0' = [\sqrt{K_0/\rho} + \sqrt{(K_0/\rho)-1}]^2$. The normalized bandwidth equations, however, take a different form:

$$\left(\frac{\omega_c' C_D}{G_D}\right)^2 = \left(\frac{h'+1}{\alpha' h'}\right)\left(\frac{1}{\sqrt{K_0'}-2}\right), \quad n = 2 \tag{3a}$$

$$\left(\frac{\omega_c' C_D}{G_D}\right)^2 = \left(\frac{h'+1}{3\beta'-1}\right)\left(\frac{1}{\sqrt{K_0'}-2}\right), \quad n = 3. \tag{3b}$$

Although the actual bandwidths are larger than for operation without a circulator, the relative increases for increasing values of n are somewhat smaller.

The third connection, denoted transmission type, has the generator and negative conductance located at one port of the filter, and the load at the other port. Again, (generally different) filter-element values for a ladder structure can be chosen to give a maximally-flat (and minimum phase) response. In general, the transmission type has less bandwidth than the reflection type, the difference becoming greater for ratios of source-to-load conductance that give lower noise factors.

$$G_L = \frac{G_D}{1+g_G-2\sqrt{\dfrac{g_G}{K_0}}}, \quad G_G = g_G G_L$$

$$n=2, \quad L_A = \frac{\alpha C_D}{G_D^2}, \quad \alpha = 1-\sqrt{\frac{2(h-1)}{2h-1}}$$

$$\left(\frac{\omega_c C_D}{G_D}\right)^2 = \frac{-(2-\alpha)+\sqrt{(2-\alpha)^2+4\left[\left(\frac{h}{h-1}\right)^2-2\right]}}{2\alpha\left[\left(\frac{h}{h-1}\right)^2-2\right]}$$

$$n=3, \quad L_A = \frac{\alpha C_D}{G_D^2}, \quad C_B = \beta C_D, \quad \alpha = 3-\frac{1}{\beta}$$

$$\beta \text{ ROOT OF, } \beta^3 - 3\beta^2 + 3(2h-1)\beta - (2h-1) = 0$$

$$X = \left(\frac{\omega_c C_D}{G_D}\right)^2 \text{ ROOT OF, } \frac{4(3\beta-1)^4}{(1-\beta)^6} X^3 - \left(3-\frac{1}{\beta}\right)^2 X^2 + \left(3-\frac{1}{\beta}\right)\left(\frac{1}{\beta}-1\right)X - 1 = 0$$

Fig. 3—Design equations for reflection type. The quantities g_G, K_0, G_D, and C_D are assumed specified. L_A is the series inductance and C_B is the second shunt capacitance in the low-pass filter.

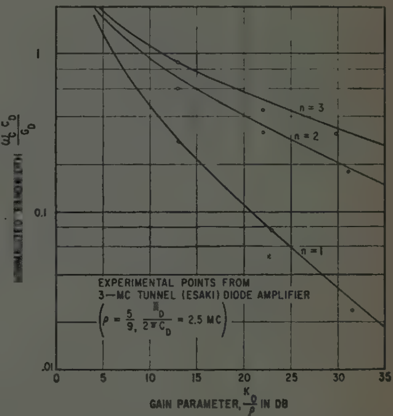

Fig. 4—Normalized bandwidths vs power gain for reflection type ($n=2$ and $n=3$) and single-tuned ($n=1$) amplifiers. The angular bandwidth (ω_c) is normalized to the figure of merit of the negative conductance, G_D/C_D.

Now, consider the asymptotic maximum gain-bandwidth performance at high gain for the three connections (Fig. 5). It can be shown that the curves for all three connections approach the same decreasing curve as n approaches infinity. Furthermore, for the reflection type operated with a circulator, the ordinate in Fig. 5 equals 2 sin $(\pi/2n)$. Thus, the gain-bandwidth products in Fig. 5 approach zero as n approaches infinity, and (contrary to Seidel and Herrmann) it is not theoretically possible to operate in the limit with nonzero bandwidth and infinite gain. Instead, there will be some value of n that maximizes the gain for a given bandwidth.

The basic experimental amplifier (Fig. 6) was a band-pass design. Fig. 7 shows a typical reflection-type maximally-flat 3-mc amplifier ($n=2$). This amplifier was de-

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* Received by the IRE, December 28, 1959. The work reported here was performed under Air Force Contract AF30(602)-1854.

[1] H. S. Sommers, Jr., "Tunnel diodes as high frequency devices," Proc. IRE, vol. 47, pp. 1201–1206; July, 1959.

[2] H. Seidel and G. F. Herrmann, "Circuit aspects of parametric amplifiers," 1959 IRE Wescon Convention Record, pt. 2, pp. 83–90.

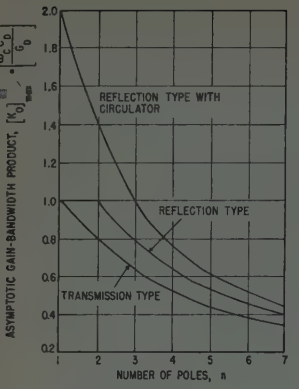

Fig. 5—Asymptotic maximum gain-bandwidth products for three connections of maximally-flat negative-conductance amplifiers vs number of poles. For the reflection type, $g_G = 1$. For the transmission type, $g_G = 1/(2n-1)$.

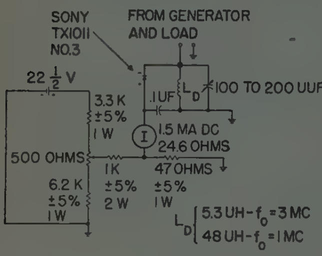

Fig. 6—Basic experimental tunnel (Esaki) diode amplifier. The dc biasing circuit was tailored to the i-v characteristics of one particular Esaki diode to permit fine control of setting to the point of maximum negative conductance.

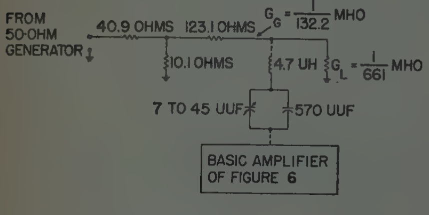
FROM 50-OHM GENERATOR
40.9 OHMS
123.1 OHMS
$G_G = \frac{1}{132.2}$ MHO
10.1 OHMS
4.7 UH
$G_L = \frac{1}{661}$ MHO
7 TO 45 UUF
570 UUF
BASIC AMPLIFIER OF FIGURE 6

Fig. 7—Typical reflection-type maximally-flat 3-mc amplifier ($n=2$). All capacitors were provided with trimming adjustments to obtain the desired maximally-flat response, as observed on an oscilloscope display of gain vs frequency.

signed for $K_0 = 100$, $g_G = 5$, $G_D = (8.39)(10)^{-3}$ mho, and C_D (diode plus tuning capacitance) $= 530$ $\mu\mu f$. The measured bandwidths of various 3-mc reflection and 1-mc transmission-type amplifiers were in good agreement with theoretical values. (See Fig. 4 for the reflection-type results.) The selected value of $g_G = 5$ results in a negligible load noise contribution, and thus the measured noise factor of 7.5 db was in good agreement with the theoretical shot noise term[3] for the particular diode used.

The author acknowledges the help of A. Barone in measurements, and helpful discussions with J. C. Greene in preparing this letter.

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Airborne Instruments Lab.
Div. of Cutler-Hammer, Inc.
Melville, N. Y.

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[3] K. K. N. Chang, "Low-noise tunnel-diode amplifier," Proc. IRE, vol. 47, pp. 1268–1269; July, 1959.

Frequency Dependence of the Equivalent Series Resistance for a Germanium Parametric Amplifier Diode*

The equivalent circuit of a zero- or back-biased germanium diode is usually represented as a parallel combination of a transition region capacitance and a dynamic barrier resistance in series with a bulk resistance. From ac junction theory and skin affect considerations, these elements would be expected to be frequency independent to frequencies beyond 1 kmc. Early measurements of the equivalent series resistance (r_s') of germanium parametric amplifier diodes[1] indicated a frequency dependence in the range from 200 mc to 1 kmc. Furthermore, there were indications that r_s' was surface dependent. The present paper reports on a series of measurements performed in different ambients, and offers a model to explain the results.

The equivalent series resistance and capacitance was measured by exploration of the standing wave pattern in a slotted line. With a sensitive receiver as a detector, standing-wave ratios of around 500 could be measured. In order to get the true junction impedance Z_L of the diode from the measured admittance Y_{in}, the following transformation was used:

$$Z_L = \frac{1}{Y_{\text{in}} - Y_0} - \frac{1}{j(B_{\text{sh}} - B_0)} \tag{1}$$

where $Y_0 = G_0 + jB_0$, and $Y_{\text{sh}} = G_{\text{sh}} + jB_{\text{sh}}$ are the open-circuited and short-circuited diode admittances. The values of Z_L are calculated on a computer from the measured standing wave ratios and shift in minimum. The above transformation has been checked against a general four-terminal transformation and good agreement has been obtained. It is estimated that the measurement is accurate to 5 per cent at around 1 kmc and may be as high as 10 per cent at lower frequencies.

The measured values of equivalent series capacitance stayed constant to within ± 0.1 $\mu\mu$fd with changing frequency, and the variation with bias was the same in the microwave region as in the low-frequency range, *i.e.*, $C_s' = C_0(1 - V/\phi)^{-1/2}$ where ϕ is the diffusion potential and V is the bias voltage. Furthermore, C_s' was not affected by the changing ambients.

The equivalent series resistance r_s' for a typical diode is shown in Figs. 1 and 2 as a function of frequency for several different ambients. The curves drawn through the experimental points were obtained by fitting a $1/f^2$ law to the points.

Although measurements were made at higher reverse bias, they are not plotted because of the larger errors inherent in the measurement at high reverse bias. It can be said, however, that r_s' appeared to be relatively independent of applied bias.

In general, r_s' was highest in ozone and lowest in wet oxygen. On the other hand, the dc reverse current is lowest in dry O_2 and higher in both ozone and wet oxygen (see Table I).

The results can be explained by assuming a constant surface resistance shunting the transition capacitance C_t. Since the Q of the diode is high, the equivalent series resistance for such a circuit is given by

$$r_s' = r_b + \frac{1}{\omega^2 C_t^2 R_{s1}} \tag{2}$$

where r_b is the bulk resistance and R_{s1} is the surface shunt resistance. Eq. (2) has been fit to the data, and it is indicated by the curves drawn through the experimental points in Figs. 1 and 2. It is seen that r_s' in ozone and dry oxygen fits (2) quite well,

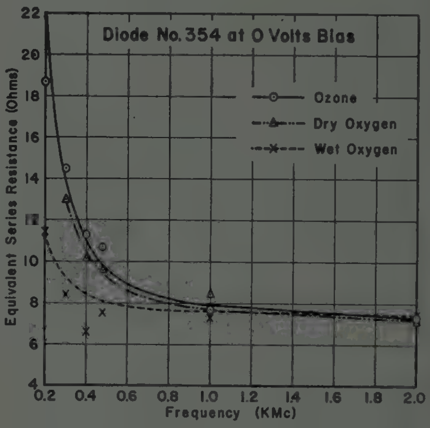

Fig. 1—Frequency dependence of equivalent series resistance, 0 volt bias.

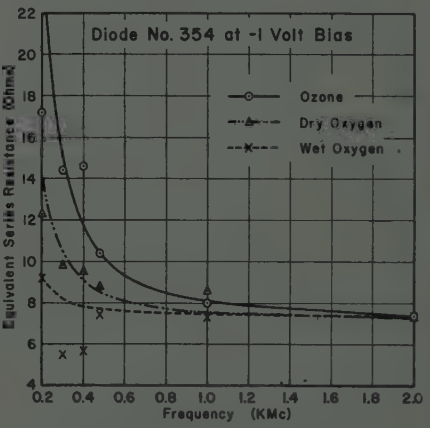

Fig. 2—Frequency dependence of equivalent series resistance, −1 volt bias.

TABLE I
Reverse Currents in Different Ambients

Ambient	Reverse Bias	I_r (mμamp)
Ozone	−1 Volt	150
Ozone	−2	260
Ozone	−3	440
Dry O_2	−1	90
Dry O_2	−2	150
Dry O_2	−3	320
Wet O_2	−1	300
Wet O_2	−2	680
Wet O_2	−3	1550

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* Received by the IRE, October 5, 1959.

[1] The measured diodes are Hughes gold-bonded germanium diodes available commercially as the HPA-2800 series. The properties of this diode are discussed in a paper by S. T. Eng and W. Waters, presented at the Natl. Electronics Conf., Chicago, Ill., October, 1959; to be published in *Proc. NEC*.

although wet oxygen shows large discrepancies at around 400 mc. In fact, wet oxygen appears to go through a minimum in this frequency range, a fact which is not presently understood.

If one considers the surface resistance R_{s1} to be the same as the dynamic low-frequency barrier resistance, a serious objection to the above model is raised when one calculates the values of R_{s1} from the data (see Table II), for it is seen that R_{s1} is about two to three orders of magnitude lower than the low frequency dynamic resistance (approximately 10 megohms at -1 volt bias). Furthermore, the expected inverse proportionality between R_{s1} and the reverse current in different ambients is not apparent (if anything they seem to be directly proportional).

One way out of this difficulty is to consider a more complete equivalent circuit for the surface. Fig. 3 shows a schematic representation of a gold bonded diode, where R_{s1} is the resistance along the surface which shunts the transition capacitance C_t, and C_s is the capacitance associated with the surface space-charge region. In addition, we shall introduce a second surface resistance R_{s2} which expresses the dependence of the reverse current on the surface generation rate, and is analogous to the diffusion resistance at the bulk junction (omitted from the diagram because it is very large compared to the reactance of C_t). It is clear that R_{s2} is in parallel with C_s in order to provide a dc current path. Although R_{s1}, R_{s2}, and C_s are represented as lumped constants, they are actually distributed over the surface and may vary from point to point.

Experimental information indicates that $C_s \gg C_t$, otherwise the measured equivalent capacitance would differ from the transition capacitance C_t. At microwave frequencies, C_s short-circuits R_{s2} so that the equivalent series resistance is still expressed by (2). However, at dc and low frequencies, the main contribution to the dynamic barrier resistance is given by R_{s2} which may be much larger than R_{s1}.

TABLE II
CALCULATED LEAKAGE RESISTANCE IN DIFFERENT AMBIENTS

Ambient	Reverse Bias	R_{s1} (K Ohm)
Ozone	0 Volt	4.7
Ozone	-1	18
Dry O_2	0	6
Dry O_2	-1	47
Wet O_2	0	18
Wet O_2	-1	156

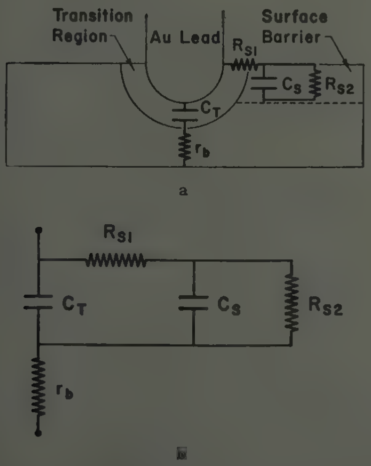

Fig. 3—(a) Schematic representation of gold-bonded diode. (b) Equivalent circuit of gold-bonded diode.

While this work was in progress, D. E. Sawyer of Lincoln Laboratories, Lexington, Mass., reported a $1/f$ frequency dependence (in the range 10 to 250 mc) for the equivalent series resistance of a variable capacity diode.[2] While our experimental conditions differ from his in several important instances (different diode structure, higher frequency range, etc.,) there is nevertheless no adequate explanation for this difference.

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[2] D. E. Sawyer, Device Research Conf., Ithaca, N. Y., June, 1959.

WWV Standard Frequency Transmissions*

Since October 9, 1957, the National Bureau of Standards radio stations WWV and WWVH have been maintained as constant as possible with respect to atomic frequency standards maintained and operated by the Boulder Laboratories, National Bureau of Standards. On October 9, 1957, the U.S.A. Frequency Standard was 1.4 parts in 10^9 high with respect to the frequency derived from the UT 2 second (provisional value) as determined by the U. S. Naval Observatory. The atomic frequency standards remain constant and are known to be constant to 1 part in 10^9 or better. The broadcast frequency can be further corrected with respect to the U.S.A. Frequency Standard, as indicated in the table; values are given as parts in 10^{10}. This correction is *not* with respect to the current value of frequency based on UT 2. A minus sign indicates that the broadcast frequency was low.

The WWV and WWVH time signals are synchronized; however, they may gradually depart from UT 2 (mean solar time corrected for polar variation and annual fluctuation in the rotation of the earth). Corrections are determined and published by the U. S. Naval Observatory.

WWV and WWVH time signals are maintained in close agreement with UT 2 by making step adjustments in time of precisely plus or minus twenty milliseconds on Wednesdays at 1900 UT when necessary; a retarding time adjustment was made at WWV and WWVH on December 16, 1959.

WWV FREQUENCY
WITH RESPECT TO U. S. FREQUENCY STANDARD

1959 1600 UT	Parts in 10^{10}†
December 1	-30
2	-29
3	-29
4	-29
5	-29
6	-28
7	-28
8	-28
9	-28
10	-28
11	-28
12	-28
13	-28
14	-28
15	-28
16	-28
17	-28
18	-28
19	-28
20	-28
21	-28
22	-28
23	-28
24	-28
25	-28
26	-28
27	-28
28	-28
29	-28
30	-28
31	-28

† 30-day moving average seconds pulses at 15 mc. Method of averaging is such that an adjustment of frequency of the control oscillator appears on the day it is made. No change or adjustment in the control oscillator was made during December, 1959.

Note: Beginning January 1, 1960, the value of the USFS has been arbitrarily increased by 74 parts in 10^{10} to bring it into agreement with a cesium resonator frequency of 9192, 631, 770 cps. See "National standards of time and frequency in the United States," National Bureau of Standards, PROC. IRE, vol. 48, pp. 105–106; January, 1960.

NATIONAL BUREAU OF STANDARDS
Boulder, Colo.

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* Received by the IRE, January 25, 1960.

The Tunnel-Emission Amplifier*

During the recent tumult caused by the "tunnel diode," this author had cause to reflect upon just what significant statements might be made concerning this device. The more important conclusions may be summarized as follows:

1) The device employs a *controlled source* of *majority carriers.*
2) Its frequency response is essentially limited by the number of majority carriers available.
3) In times past many negative resistance devices have been introduced, but in the course of time have given way to stable three-terminal amplifying devices.

Once interest in a negative resistance is abandoned, it becomes clear that semiconductors are of questionable value, since their carrier densities are inherently quite low. Metals with very large electron densities may be used as a carrier source, and insulators provide the necessary forbidden regions.

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* Received by the IRE, December 28, 1959.

SURFACE TUNNELING

Let us consider the behavior of a metal-insulator-metal layer structure with a voltage impressed between the two metal layers. A simplified energy band picture of such a structure is shown in Fig. 1(a). Under the bias condition shown, electrons near the Fermi level in the negative metal may "tunnel" through the forbidden region into the insulator conduction band and thus make their way to the positive metal. In order to find the total tunnel current we must find the number of electrons per second incident on the junction as a function of energy, multiply by the tunneling probability which will also depend upon the energy, and integrate over the available electron energies. An approximate expression may be obtained by assuming a "hard" Fermi sphere in the metal, an insulator whose forbidden region is centered on the metal Fermi level, and neglecting the contribution of electrons appreciably below the Fermi level. The results of such calculations are

$$J \approx J_0 \frac{\pi V_1}{2V_f} \frac{E}{E_0} e^{-E_0/E} \tag{1}$$

where

$$J_0 = \frac{3qN_0\hbar k_f}{4m},$$

$$E_0 = \frac{qmaV_1^2}{\hbar^2},$$

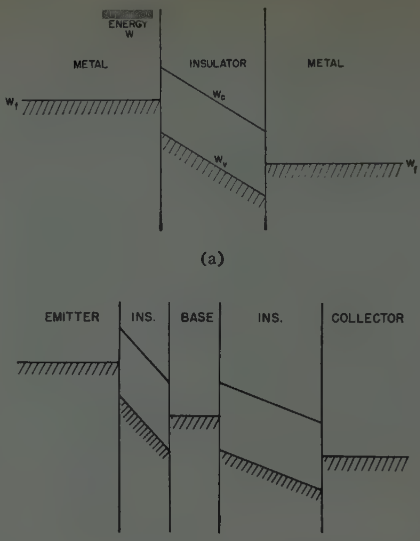
V_1 is half the insulator forbidden band gap,
V_f is the metal Fermi level,
k_f is the wave number of an electron at the metal Fermi level,
N_0 is the electron density in the metal,
m is the electronic mass, and
q is the electronic charge.

Since the tunneling distance for electrons in the metal is much shorter than for insulator valence electrons, tunneling from the metal would be expected to dominate the process by a considerable margin. The values for aluminum and aluminum oxide are

$$J_0 \approx 10^{12} \text{ amp/cm}^2$$

$$E_0 \approx 1.5 \times 10^8 \text{ V/cm}.$$

The tunnel current as a function of electric field is shown in Fig. 2.



(a)

(b)

Fig. 1—Simplified energy band models for (a) diode, and (b) triode.

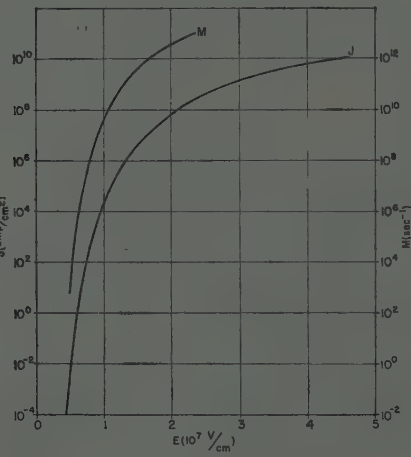


Fig. 2—Tunnel current density and figure of merit as function of electric field.

TUNNEL EMISSION

Suppose we make the positive metal layer thin compared with an electronic mean free path. Electrons tunneling from the negative metal "emitter" on the left into the insulator conduction band may continue through the thin metal base. Those which possess sufficient momentum to overcome the metallic work function will be emitted from the surface to the right.

This structure may be useful as a "tunnel cathode" for conventional or microwave tubes, or it may be used as the emitter of a transistor-like three-terminal amplifier.

Let us place to the right of the thin metal "base" region another insulating layer and then a metal "collector." The simplified energy band picture for such a configuration is shown in Fig. 1(b). Electrons tunneling through the thin "base" region now find themselves in the conduction band of the second insulator, and provided the collector is biased positively, will be accelerated to the right and hence collected. Such a device may be characterized in much the same way as a transistor, and the same considerations concerning gains and impedances apply. In the common base connection, power gain is obtained as a result of the impedance transformation between input and output.

FREQUENCY LIMITATIONS

Since the tunneling itself occurs in an extremely short time, we should expect the operating frequency to be limited by the rather large input capacitance. Using as a figure of merit

$$M = \frac{1}{RC} \tag{2}$$

where R is the incremental input resistance and C is the input capacitance, we may estimate the frequency limitation from (1);

$$M \approx \frac{J_0 E_0 e^{-E_0/E}}{\epsilon E}.$$

This equation has been evaluated in terms of the electric field and plotted along with the current density in Fig. 2. At a field of 1.5×10^7 v/cm the current density would be of the order of 4×10^6 amp/cm² and M would be nearly 10^{12} cps. The real limiting factor appears to be just how small the devices may be built in order to keep the current density at as high a value as possible. Since there will always be some lateral current in the thin base region, current crowding problems will exist as in the transistor. Also such high currents will cause local heating of the metal and place a limit on the operating densities. The space charge limitation for typical geometries is of the order of 10^9 to 10^{10} amp/cm² and hence should not be a problem. It is clear that the input circuit must work at very low impedance levels, just as the negative resistance "tunnel diode."

EXPERIMENTAL RESULTS

The first observations of surface tunneling were made on diodes constructed as follows: A relatively thick film of aluminum was evaporated on a glass substrate and subsequently anodized in a nonsolvent electrolyte. This method produced Al_2O_3 films whose thickness was calculated from the known oxide growth rate to be between 60 and 80 Angstroms. Many small aluminum squares were then evaporated over the oxide. Tunnel current was observed to begin very abruptly at fields of one to two times 10^7 volts/cm. The results were quite reproducible between units on one anodized film, but varied by as much as a factor of two between different films.

Triodes were made in the same manner, except the second aluminum evaporation was carefully controlled to give a thin base layer (about 100 Å). Silicon monoxide was then evaporated over the entire area to a thickness of several hundred Angstroms. A thick aluminum collector was evaporated over the insulating film. Tunnel current at the collector was observed to begin very abruptly at emitter-base fields of the same magnitude as in the diode. For the units tested, the emitter-collector current transport factor (α) was between 0.1 and 0.3, increasing markedly as the current density increased. This behavior is to be expected from such a device where surfaces may contribute a large number of trapping states.

All units were destroyed at rather small currents (less than 1 ma) indicating that the tunneling had occurred over one very small area. Again this behavior is to be expected from the rather crude techniques employed.

CONCLUSION

The devices described here are inherently capable of extremely high frequency performance. To realize their theoretical capabilities, however, a large amount of development effort will undoubtedly be necessary. The purity of materials and refinement of technique presently applied to transistors will be very valuable. With the advances in understanding and technique that accompany any new device, the tunnel-emission amplifier may be expected to extend the useful frequency range of solid state devices beyond that now attainable by a considerable margin.

ACKNOWLEDGMENT

The author wishes to extend special thanks to D. G. Dow for many helpful discussions and suggestions, and R. A. Baugh for his assistance in the experimental work.

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A Low-Level Pulse-Height Standard*

There has been an absence of circuits which can be used to produce calibrated, short, low-level pulses. The circuit in Fig. 1 shows a method of producing calibrated low-level pulses in the range zero to two volts to accuracy of better than one-half per cent of full range. The accuracy is limited on short pulses by the overshoot of the transistor; however, new high frequency transistors can be made to operate very well in this respect. A 2N502 transistor can be used for pulses down to 0.2 μsec with rise and fall times of 0.08 μsec.

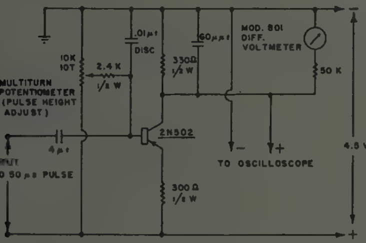

Fig. 1—Standard pulse generator.

The circuit operates by turning on the transistor to a level of conduction determined by the bias setting, and then turning off the transistor during the pulse. The dc collector voltage is measured by a high impedance differential voltmeter. The circuit drive is adjusted for clean "saturation" with no overshoot, so that the dc collector voltage is equal to the height of the output pulse. This may be checked by applying a variable pulse width to the input and observing overshoot while adjusting drive. The multiturn potentiometer used in the base circuit adjusts the amplitude of the output pulse. The 60 μμf capacitor is a compensating capacitor to improve the wave shape. The 50K resistor in series with the voltmeter is used to isolate the circuit from the voltmeter input capacitance.

The circuit is designed to operate with low-pulse duty cycles which contribute very little error to pulse height measurement. The 2N502 should be selected for low leakage, dependent on the pulse height accuracy required in the circuit.

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* Received by the IRE, September 14, 1959.

On the Generality of "Near-Zone Power Transmission Formulas"*

In his correspondence,[1] J. Robieux claimed that my paper[2] gives some results of work on energy transmission from a transmitter to a receiver, *previously* published by him in a *more general* statement. This is misleading. For the purpose of clarification, I would like to present a few facts which show that his result was not obtained or published previous to mine, and also that my result, in my opinion, is really *more* general.

First, I would like to make it clear that I obtained my result without any knowledge of Mr. Robieux's work on a similar formula. This is supported by the following dated written and published records. My work on near-zone transmission relations was a part of a research project on "Study of Near-Zone Fields," sponsored by Rome Air Development Center, Rome, N. Y., under Contract No. AF30(602)-928. This particular result was obtained in the later part of 1955. Statements concerning this result can be found in the letter progress reports, each in a number of ditto copies, to the sponsor in March, 1956, and June, 1956. The final report of this project, including two parts, was written in April, 1957, and these transmission relations were included as one chapter in part two.[3] In October, 1957, an abstract and a summary, based upon this chapter, were sent to the IRE, and were presented at the 1958 IRE National Convention in March and published in the 1958 IRE NATIONAL CONVENTION RECORD. By comparing the dates given here and those given by him, the word *independently* may be more appropriate than the word *previously* for the description of the situation.

Secondly, he proved the formula under a number of unnecessary assumptions,[4,5] such as the following.

1) Each antenna has a directivity such that it radiates into, or receives from, only one hemisphere.

2) The two antennas are far apart so that the radiation of one is unaffected by the other.

3) The two antennas are sufficiently far apart that the $\overline{E}$ and $\overline{H}$ radiated by the same antenna are in phase.

The use of these assumptions in his proof restricts the possible applications of his result and therefore makes his result less general. I did not use any one of these assumptions except for special approximate forms. On the other hand, I used the condition that the two antennas are simultaneously matched.[2] In my opinion, this condition is essential in the proof of the form given, but it was not stated explicitly in Robieux' two papers.[4,5] However, a matched condition of special form which is applicable under his restrictive assumptions did appear in his correspondence.

Finally, I do agree with him completely that these formulas can be considered as very general ones in physics. They can be generalized to include anisotropic medium and can also be extended to fields other than electromagnetic theory.

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* Received by the IRE, July 10, 1959.

[1] J. Robieux, "Near-zone power transmission formulas," PROC. IRE, vol. 47, pp. 1161; June, 1959.

[2] M. K. Hu, "Near-zone power transmission formulas," 1958 IRE NATIONAL CONVENTION RECORD, pt. 8, pp. 128–138.

[3] M. K. Hu, "Study of Near-Zone Fields of Large Aperture Antennas," Syracuse University Res. Inst., Syracuse, N. Y., Final Rept., pt. 2, pp. 72–84; April, 1957.

[4] J. Robieux, "Interaction entre onde rayonnée et onde de surface et son application à la propagation lointaine," *L'onde Electrique*, vol. 37, pp. 1089–1097; December, 1957.

[5] J. Robieux, "Interaction entre deux aériens," *Compt. rend. Acad. Sci.*, vol. 245, pp. 793–796; August, 1957.

A Microwave Adler Tube*

Adler *et al.*[1] have recently described an electron beam parametric amplifier with a noise figure of 1.4 db (for double channel operation) working in frequency bands between 400 and 800 mc. This amplifier makes use of "fast" transverse cyclotron waves excited on the electron beam in the presence of a longitudinal magnetic field.

We have now built an amplifier, identical in principle but operating in the microwave region at 4140 mc. First experiments have yielded a noise figure of 2.5 db for double channel operation (noise temperature of 225°K). Gains of up to 24 db with a bandwidth of 67 mc to 3 db points have been achieved.

Fig. 1 shows the arrangement of the important parts of the tube, which was operated in a continuously pumped demountable system. (Also see Table I.) Instead of the lumped circuits of Adler's tube, resonant cavities are used. The input and output cavities are identical and are arranged to produce an RF electric field transverse to the beam.[2] They are resonant at the signal frequency (4140 mc) which is approximately equal to the cyclotron frequency of the longi-

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* Received by the IRE, October 30, 1959; revised November 12, 1959.

[1] R. Adler, G. Hrbek, and G. Wade, "The quadrupole amplifier, a low noise parametric device," PROC. IRE, vol. 47, pp. 1713–1723; October, 1959.

[2] C. L. Cuccia, "The electron coupler," *RCA Rev.*, vol. 10, pp. 270–303; June, 1949.

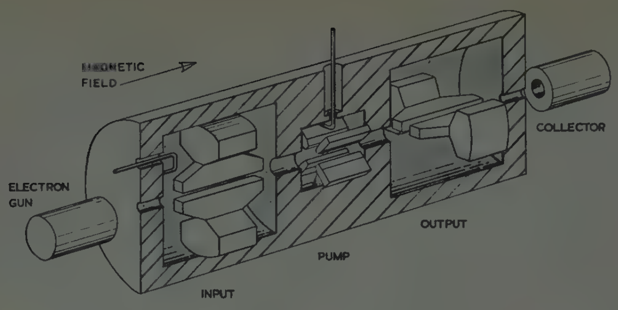

Fig. 1—Microwave Adler tube for 4000 mc.

TABLE I
TUBE DIMENSIONS

1) Input and output cavities	
Plate length	0.53 inch
Plate width	0.035 inch
Plate spacing	0.043 inch
Cavity diameter	0.8 inch
Cavity length	0.76 inch
2) Pump cavity	
Plate length	0.125 inch
Plate spacing (along a diameter)	0.046 inch
Cavity diameter	0.40 inch
Cavity length	0.38 inch
3) Beam diameter	0.015 inch

TABLE II
ELECTRICAL CHARACTERISTICS

1) Input and output cavities	
Resonant frequency	4140 mc
Unloaded Q	1820
Unloaded shunt impedance	87,500 ohms
Loaded Q (cold)	180
Input VSWR (cold)	9.2
2) Pump	
Resonant frequency	8300 mc

TABLE III
TYPICAL OPERATING CHARACTERISTICS

Magnetic field	1480 gauss
Beam voltage	17.5 volts
Beam current	70 microamps
Pump power into pump cavity	107 mw
Signal gain (band center)	19.5 db
Bandwidth to 3-db points	4107 to 4174 mc =67 mc
Input line loss	0.2 db
Cavity losses	0.56 db each
Dynamic range (in a 2-mc band)	80 db

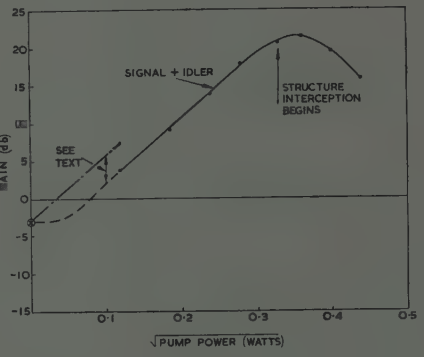

Fig. 2—Gain plotted against the square root of pump power. Conditions as in Tables II and III; signal input level −90 dbm.

tudinal magnetic field. The pump cavity has four poles and is operated in the π mode. producing a quadrupolar field. It is resonant at the pump frequency (8280 mc) which is approximately twice the signal frequency. The cavities are fed by coaxial lines and loops. The whole tube is immersed in a uniform longitudinal magnetic field of 1480 gauss. A standard 3-anode low-noise traveling-wave tube gun is used. In most of the tests the cathode diameter was 0.026 inch, but the beam diameter was limited to approximately 0.015 inch by apertures in two of the gun anodes. Similar results have been obtained with a 0.015-inch diameter cathode and no limiting apertures. Typical values of beam voltage and current are 17 volts and 70 microamps. The collector is specially designed to prevent secondary electrons returning down the tube.

The operation of the tube is very similar to that of the low frequency tube.[1] With correct adjustment, the input and output cavities act as nearly perfect couplers to a fast cyclotron wave of infinite phase velocity on the beam. In this wave each electron executes an orbiting motion at the cyclotron frequency with all orbits having the same radius and phase. The input cavity feeds all the signal power (circuit losses apart) onto the beam and strips all the noise signal from the beam. The output cavity strips the amplified signal from the beam and feeds it to the output line. In the absence of pump power, signal power is transferred from the input to the output line with some small amount of loss in the cavities. With the pump power on, the signal wave is amplified in the pump cavity, and at the same time an idler wave is generated, which at high gain is of the same amplitude as the signal wave. The extra power in the amplified waves comes, of course, from the pump, and not from the dc beam. The frequency of the idler is the difference between the pump and signal frequencies. If both signal and idler frequencies are within the operating band of the output coupler, both will be stripped off and fed to the output line.

Some of the measured electrical characteristics of the tube are given in Table II and some typical operating conditions in Table III. Fig. 2 shows measured gain plotted against the square root of pump power. In this measurement, signal and idler frequencies were practically equal and both were accepted by the detecting receiver which had a bandwidth of 2 mc. According to theory[1,3] the maximum db gain in true degenerate operation is strictly proportional to the square root of pump power at all values of pump power. Because of cavity and other losses, the gain at zero pump power will in practice be slightly negative. When the pump is not phase locked to the signal, the db gain is also proportional to the square root of pump power at high gain, but there is a 3-db penalty (taking signal and idler together) and a 6-db penalty for signal alone. In the present experiment, therefore, the gain points at high gain should lie on a straight line, but the point for zero pump power should lie on the line which would be obtained for degenerate operation, 3 db above this. Fig. 2 shows that below saturation the behavior is roughly as predicted. Of the loss at zero pump power about 1.4 db is due to circuit loss. The rest is probably due to accidental detuning of the output cavity.

Saturation occurs above 20 db net gain, due to beam current interception. Up to the point indicated on the curve, the measured interception is zero, but above this point it suddenly starts to rise. A possible explanation of this follows from the ideas of Lea-Wilson[4] concerning noise in Adler tubes. He points out that the random noise orbits of the electrons leaving the cathode are not removed by the input coupler; only an imperceptible rearrangement occurs, whereby the noise which can be coupled to an external circuit is reduced to zero. These noise orbits can be amplified in the same way as the signal; if they get too large, electrons will strike the cavity posts causing interception and loss of gain.

If the cathode temperature T is 1000°K the average transverse energy of emitted electrons is kT (where k is Boltzmann's constant) or 0.086 volt. Four per cent of the electrons have a transverse energy exceeding $2kT$ or 0.172 volt. In the present case, this gives an orbit radius before amplification of 2.7×10^{-4} inches for kT electrons and 3.8×10^{-4} inches for $2kT$ electrons. From the electronic gain at the point of incipient structure interception one can readily compute[1] the maximum orbit radius after amplification. It is 5.4×10^{-3} inches for kT electrons and 7.6×10^{-3} inches for $2kT$ electrons. The nominal clearance between the beam and the cavity posts is 14×10^{-3} inches. It would appear, therefore, that expansion of the beam due to amplification of noise orbits is of the right order to explain current interception and gain saturation.

Gain saturation due to a CW signal is shown in Fig. 3. Saturation starts at a signal input of −20 dbm with a total gain of 22.5 db, corresponding to a signal gain of 19.5 db and an output signal power of 8.9×10^{-4} watts. The calculated[3] orbit radius corresponding to this power is 3.2×10^{-3} inches. The maximum orbit radius due to signal and idler together is double this figure, or 6.4×10^{-3} inches. This is approximately the same size as the noise orbits which produced saturation in the previous experiment. It seems probable, therefore, that signal saturation is also a result of beam expansion due to amplification of the orbits.

The bandwidth of the tube is shown in Fig. 4. The measurement receiver had a bandwidth of 2 mc. The bandwidth to points 3 db below the gain at band center is 67 mc. It is important to note that the electronic gain is constant with frequency. This means

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[3] W. H. Louisell, private communication.

[4] C. P. Lea-Wilson, "Some possible causes of noise in Adler tubes," PROC. IRE, vol. 48, pp. 255–256; February, 1960.

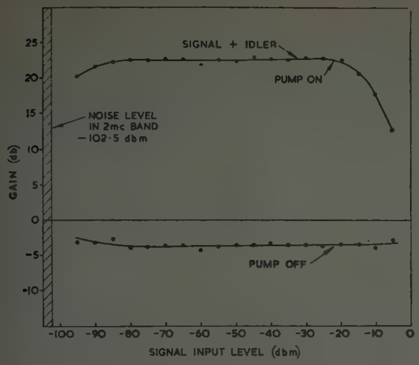

Fig. 3—Gain with pump on, and insertion loss with pump off plotted against input signal level. Conditions as in Tables II and III; pump power into pump cavity 107 mw.

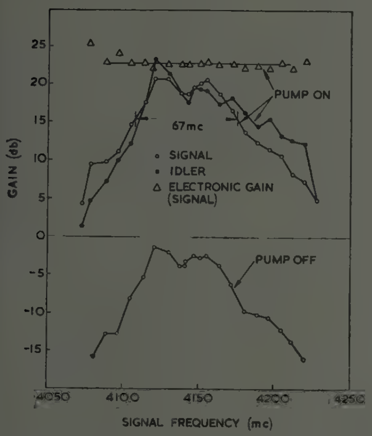

Fig. 4—Gain for signal and idler with pump on, signal loss with pump off, and electronic gain plotted against frequency. Conditions as in Tables II and III; pump power into pump cavity 107 mw.

that the bandwidth is not limited by the gain mechanism in the pump cavity, but simply by the input and output couplers. In the present case it is the Q of the coupling cavities rather than the coupling mechanism to the cyclotron wave that determines the bandwidth. The loaded Q of the cavity with the beam on is about 100 for a matched input. This yields a calculated bandwidth of 41 mc. The larger measured bandwidth is probably due to accidental detuning of the output cavity as mentioned above. A relative shift of 37 mc between input and output cavities gives a calculated bandwidth of 67 mc and a 1.5-db transmission loss.

Noise has so far been measured at the band center only, within a bandwidth of 2 mc. The best result obtained has been an effective input noise temperature of 225°K, corresponding to a noise figure of 2.5 db for double band working.

The authors thank Dr. R. Kompfner for suggesting this work and A. J. Rustako, Jr. for constructing much of the apparatus.

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On the Regenerative Pulse Generator*

Experimental as well as theoretical work on the millimicrosecond pulse generator has been reported by Cutler.[1] Also, Edson[2] has pointed out the possibility of interpreting Cutler's circuit as a multimode oscillator. In the following, a more detailed analysis based on this point of view will be presented. For this, we shall assume a circuit as illustrated by the block diagram of Fig. 1. The proper choice of external signal, external gain variation, and nonlinear characteristic, as well as transmission of the feedback network, will assure a maximum variety of possible steady-state waveforms.

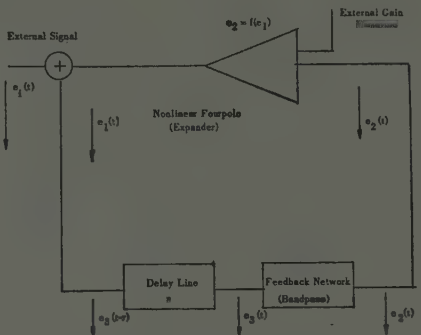

Fig. 1—Block diagram of a regenerative pulse generator, or multimode oscillator.

Upon closer investigation of the general problem, one realizes that the strictly academic assumption of an ideal, flat system with an infinite number of modes will permit us to obtain some interesting results with relative ease. Thus we discard the feedback network, (Fig. 1), which provides frequency selectivity in the loop, and accordingly have

$$e_3(t) = e_2(t). \tag{1}$$

With the feedback equation

$$e_1(t) = e_2(t - \tau), \tag{2}$$

and with the nonlinear characteristic

$$e_2(t) = f[e_1(t)], \tag{3}$$

we obtain a nonlinear difference equation to describe our system. (For our analysis we disregard forced oscillations, and assume $e_i(t) = 0$.)

Although there will be no small signal transmission in an ideal expander, the mode frequencies obtained from a linearized analysis[3] as

$$\omega = \frac{2n\pi}{\tau} \tag{4}$$

will also have significant meaning in the present case.[4]

The difference equation obtained from combination of (2) and (3) has periodic solution functions $P(t)$ with a period τ, and thus we can prescribe:

$$e_1(t) = P(t) = P(t + m\tau). \tag{5}$$
$$(m = 1, 2, 3 \cdots).$$

Specifically, by substituting (3) into (2), and assuming a solution (5) as defined above, we readily obtain

$$P(t) = f[P(t - \tau)] = f[P(t)]. \tag{6}$$

Eq. (6) has to hold at all times, and for $f(e_1)$ being a polynomial in e_1, we obtain an algebraic equation in $P(t)$, which may have real solutions:

$$\begin{aligned} P_1(t) &= p_1 \\ P_2(t) &= p_2 \\ &\cdots \\ P_n(t) &= p_n. \end{aligned} \tag{7}$$

The p_ν are constants, or functions which are trivially periodic in τ, and it is easily seen that a step-function which alternates between the various values p_ν and which is periodic in τ, is the general solution of our system. A single sinusoid, or a finite combination of sinusoids, cannot be a solution of the system of infinite bandwidth, assumed for our considerations, due to generation of harmonic and combination frequencies in the nonlinear fourpole.

The solutions of (6) are conveniently visualized by a graphical representation, as shown in Fig. 2.

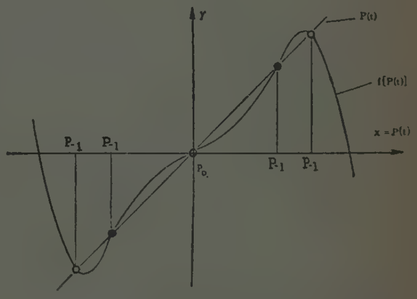

Fig. 2—Graphical solution of the nonlinear difference equation for a fifth-order nonlinearity. ○ stable ● unstable.

For our investigations of expander action, the nonlinearity is assumed to be represented by a fifth-order polynomial containing odd powers only, as specified by

$$\begin{aligned} e_2(t) &= f[e_1(t)] \\ &= \mu e_1(t) + \rho e_1^3(t) + \eta e_1^5(t). \end{aligned} \tag{8}$$

We may find five real solutions, p_ν, corresponding to the intersection with the feedback line, as indicated in Fig. 2. It is well

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* Received by the IRE, July 13, 1959.

[1] C. C. Cutler, "The regenerative pulse generator," Proc. IRE, vol. 43, pp. 140–148; February, 1955.

[2] W. A. Edson, "Nonlinear Effects in Broadband Delay Type Feedback Systems," *Proc. Symp. on Nonlinear Circuit Analysis*, Polytech. Inst. of Brooklyn, N. Y., pp. 41–53; April 25–27, 1956.

[3] V. Met, "On multimode oscillators with constant time delay," Proc. IRE, vol. 45, pp. 1119–1128; August, 1957.

[4] The phenomenon mentioned by Cutler[1] that a 180° phase shift in the loop shifts the lines observed on a spectrum analyzer, with the circuit in operation, by half their spacing in frequency, is readily attributed to basic properties of multimode oscillators. Such phase reversal changes the resonance length of the loop by one-half a wavelength, and a corresponding shift of all mode-frequencies by approximately half the mode-spacing at center band results.

known that for the above simple type of nonlinearity there always appear stable and unstable singularities along the nonlinear characteristic in consecutive order, and here we may rule out p_1 and p_{-1} as unstable. The proof of this statement follows the usual perturbation approach and is readily obtained. From an analogous argumentation, we also can rule out p_1, p_{-1} as possible values in our step-functions, since otherwise disturbances would grow in the time intervals corresponding to these values. Making use of the special properties of our step-functions, this statement may also be verified analytically by methods analogous to some to be presented later.

Thus we can expect a stable solution of our system, as shown in Fig. 3.

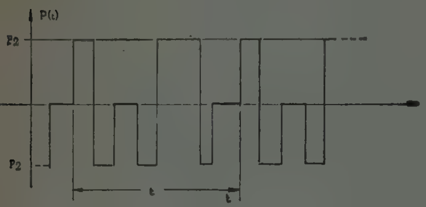

Fig. 3—Step-function, representing the general steady state solution.

Although this type of function is an arbitrary one to a large extent, it demonstrates some basic properties of physical systems.

1) The spectral lines of the corresponding energy distribution are spaced $2\pi/\tau$ radians, and it is easily seen that they coincide with the mode frequencies defined in (6).
2) The fact that $p_0=0$ constitutes a stable solution leads to pulse character of the waveform, *i.e.*, zero amplitude may be maintained during portions of its duration. This is the significant difference from a system with small signal loop-gain, which will lead to square-wave type waveforms where zero amplitude cannot be maintained during any finite time interval.

Stability of our general solution, $P(t)$, is readily shown through the following argumentation: Assume a small perturbation function δp such that

$$e_1(t) = P(t) + \delta p. \tag{9}$$

Transmission of this combination through the nonlinear fourpole renders

$$\begin{aligned} e_2(t) = \mu[P(t) + \delta p] + \rho[P^3(t) + 3P^2(t)\delta p] \\ + \eta[P^5(t) + 5P^4(t)\delta p], \end{aligned} \tag{10}$$

where small quantities are neglected.

It is easily realized from inspection of Fig. 3 that

$$P^2(t) = \left\langle \begin{matrix} p_2^2 \\ 0 \end{matrix} \right\rangle = \text{const.}, \tag{11}$$

and thus we have[5] a disturbance term:

$$\delta e_2 = (\mu + 3\rho p_2^2 + 5\eta p_2^4)\delta p. \tag{12}$$

The coefficient of δp in (12) is independent of time, due to the special properties of the otherwise largely arbitrary function $P(t)$ recognized above.[6] A necessary condition for stability of $P(t)$ is that the absolute value of the above coefficient is less than unity, which condition may be expressed by the inequality.

$$\rho p_2^2 - 2(1 - \mu) > 0, \tag{13}$$

where

$$p_2^2 = -\frac{1}{2\eta}\left[\rho + \sqrt{\rho^2 + 4\eta(1-\mu)}\right]. \tag{14}$$

Eqs. (13) and (14) specify the separatrix

$$\rho^2 + 4\eta(1 - \mu) = 0, \tag{15}$$

which is immediately recognized as the condition that (6) has five distinct, real roots. Thus, $P(t)$ is always stable if such roots may be found for the case of the fifth-order polynomial which represents a good approximation of physical cases. As shown in Fig. 3, the idealized system will indefinitely preserve a waveform, which has been forced upon it by initial conditions, for example, by an external signal $e_i(t)$. Corresponding to the infinite number of degrees of freedom of our system, this waveform is seen to be of rather arbitrary character. In the following, we shall attempt to discuss some properties of physical systems, by combining the results just obtained with previous ones and by using empirical reasoning.

DISCUSSION OF STABILITY AND CONCLUSIONS

The most important factor which enters the considerations for physical systems is bandwidth. Thus, we will always have a finite set of mode frequencies, and it seems plausible to assume that all modes have to contribute to the steady state. This is due to harmonic and combination frequency generation in the nonlinear expander. Also, the amount of dispersion in the loop, which, for convenience, may be attributed to the transfer phase of the feedback network, will be an important influence on stability and the shape of the waveform. Stability tests for physical systems thus have to take into account phase shift, the discussion of which would exceed the present space.

For the case of our special interest, the recirculative RF pulse generator, we have to accept the hypothesis that a "bandpass transformation" is permissible, which makes our previous results applicable to the waveform envelope. Again our set of mode frequencies will define the spectral energy distribution, all modes contributing to the steady state. Pulse length should thus correspond to approximately twice the reciprocal bandwidth, unless jumps in carrier frequency occur. (This phenomenon should only be possible for multiple hump characteristics, and is rather unlikely to appear for a loop transmission peaked at the center and decreasing smoothly toward the edges of the band.)

As shown by Cutler's work,[1] a system with restricted bandwidth and a frequency characteristic of the general nature of the Gaussian type generates pulses of approximate length $2/\Delta f$. Our idealized system was capable of sustaining any group of rectangular pulses, as long as they were periodic in τ, and we could venture to assume that this is also true for restricted bandwidth, for pulses of correspondingly defined length and "rounded off" shape. Thus, such a system could serve as a regenerative pulse memory, using binary pulse/no pulse or phase script (where a 180° carrier phase shift distinguishes between binary states).[7]

Experimental evidence obtained in the laboratory demonstrated the possibility of recirculation of several pulses within each interval[8] τ. This may be accomplished by periodic gain variations within the feedback loop.[9] For example, if a sinusoidal gain variation with period τ is employed, one obtains single pulse recirculation. For gain variations with a period τ/n, one could circulate n pulses, which constitutes the possibility of introducing a clock-frequency for memory applications. Also, certain phase correction methods should represent another possibility of forcing stability of special wavetrains in the system, for phase-script applications.

Although most of the conclusions which have been presented were obtained following a somewhat intuitive approach, there is sufficient experimental evidence that they definitely should be valid. Specific evaluation to obtain rigorous conclusions would lead to the analytical path pointed out by Cutler, which is difficult at best. Still we could demonstrate the largely arbitrary character of steady-state waveforms to be expected, and outline a procedure for appropriate stabilization.

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[5] Since $0 \leq \mu < 1$, for all cases of interest here, no unstable disturbance δe_2 can arise for $p^2(t)=0$ in (11).

[6] This is directly true for square-wave type functions only, which do not assume zero value for any finite time. However, one can convince oneself that stability also holds if the waveform does assume zero value, as in pulse-trains.

[7] M. P. Forrer, L. Fein, and V. Met, "Microwave Techniques for Computer Applications," Quarterly and Final Report on ONR Contr. NONR-2127(00); December, 1956 and December, 1958.

[8] In Cutler's experiments, an automatic gain-control was employed to obtain single-pulse recirculation.

[9] S. Frankel, private communication.

The Electron Content and Distribution in the Ionosphere*

Recordings of the Faraday rotation rate on the radio transmissions of the satellite 1958Δ 2 at frequencies of 20.005 and 40.01 mc have been analyzed to determine the electron content and distribution in the ionosphere. During the period of observation from November, 1958 to May, 1959, for passes in a north to south direction near Columbus, Ohio, the satellite height has varied within the range of 1227 to 1545 km.

* Received by the IRE, August 17, 1959. This work was partially supported by the USAF through the Wave and Propagation Group, Wright Air Dev. Center, Wright-Patterson Air Force Base, Dayton, Ohio.

If the region of observation is in the vicinity of the apogee or perigee of the orbit and the frequency is sufficiently high, dependent on the electron density level existing at the time of the measurement, then, for a plane earth approximation, the electron content below the satellite may be determined from the expression[1]

$$N_h = \frac{\pi h f^2}{2.97 \times 10^{-2} H v T}, \tag{1}$$

where

N_h = electron content in a column of height h and 1 square meter in area,
h = satellite height in meters,
f = frequency in cps,
H = mean value of the earth's magnetic field in the direction of motion of the satellite in amps/meter,
v = the satellite velocity in meters/sec,
T = time between adjacent nulls of the Faraday rotation in seconds.

The value of the earth's magnetic field used to compute the electron content is determined on the basis of an assumed Chapman distribution of electrons with height, and from tables of the earth's magnetic field variation with height.[2] Thus, a mean value of magnetic field is obtained which is dependent on the satellite height.

Values of electron content obtained during the period March, 1959 to May, 1959 for satellite passes meeting the requirements for the approximations used in deriving (1) are plotted as a function of local time in Fig. 1. Unfortunately, the satellite height for each measurement was not constant and, for the data shown, varied between 1227 and 1350 km. Thus, some scatter of the measured points would be expected because of this height variation, but as the electron density is relatively low at these heights the scatter is probably small compared with the daily variations in the level of electron density shown by conventional ionospheric sounding apparatus. The highest values of electron content occur, as expected, in the early afternoon with a range of 8.5 to 5.5 $\times 10^{17}$ electrons. A mean value of 6.9×10^{17} electrons is obtained for the period between 1330 and 1630 hours.

Earlier measurements during November, 1958 to January, 1959 for the near midnight period are shown in Fig. 2. The variation of the satellite height is greater in this case but its effect on the electron content will be less than for the daytime measurements as indicated later by the change in electron distribution. A mean value of 1.1×10^{17} electrons is obtained near midnight.

From the data shown in Fig. 1 and Fig. 2, it can be estimated that variations in electron content of 6:1 can occur between the early afternoon and near midnight periods of the day.

Of considerable importance in estimating the variation of electron density with height above the earth is the electron distribution ratio defined by

$$R = \frac{\text{Number of electron above the } F_2 \text{ layer maximum density}}{\text{Number of electrons below the } F_2 \text{ layer maximum density}} = \frac{N_{f+}}{N_{f_2-}}.$$

As the number of electrons below the F_2 maximum can be obtained from ionospheric soundings from the earth, the electron distribution ratio may be found from the relationship

$$R = \frac{N_h - N_{f_2-}}{N_{f_2-}}$$

where N_h is determined from (1) for a suitable satellite orbit.

Figs. 3 and 4 show the electron distribution ratio obtained for the midnight and noon periods during November, 1958 to January, 1959. The number of electrons below the F_2 maximum was calculated from critical frequency data[3] for the Washington area (approximately at the same latitude as Columbus) and the assumption of typical distribution of electrons in the F_2, F_1, E, and E_s regions.[4] The mean value of the electron distribution ratio is found to be 3.1 during the noon period and 0.96 during the midnight period. Therefore, it is concluded that the distribution of electrons with height above the F_2 layer maximum varies considerably during the midnight to noon period.

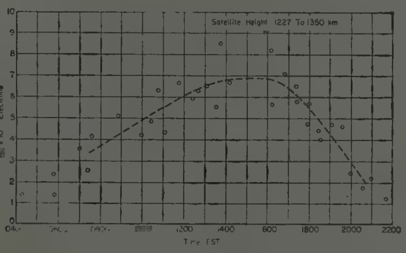

Fig. 1—Electron content during the period from March, 1959 to May, 1959.

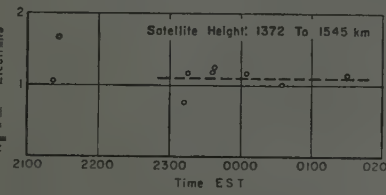

Fig. 2—Electron content near midnight during the period from November, 1958 to January, 1959.

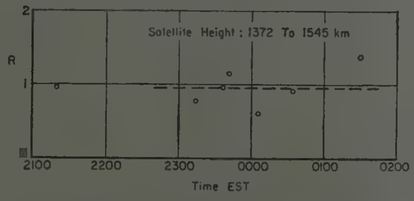

Fig. 3—Electron distribution ratio near midnight during the period from November, 1958 to January, 1959.

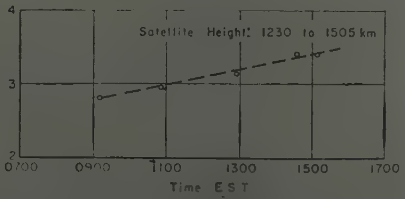

Fig. 4—Electron distribution ratio near midday during the period November, 1958 to January, 1959.

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[1] T. G. Hame, and W. D. Stuart, "The Faraday Rotation of Radio Transmissions from Earth Satellites and the Electron Density in the Ionosphere," Antenna Lab., The Ohio State Univ. Res. Found., Columbus, Rept. 889-5; August 1959.

[2] E. H. Vestine, *et al.*, "The Geomagnetic Field, Its Description and Analysis," Carnegie Institution of Washington, Washington, D. C., publication 580; 1947.

[3] "Detailed Values of Ionospheric Characteristics and F-plots for Washington," Central Radio Propagation Lab., Natl. Bur. of Standards, Boulder, Colo.

[4] G. H. Millman, "An Analysis of Tropospheric, Ionospheric and Extraterrestrial Effects on V.H.F. and U.H.F. Propagation," General Electric Co., Syracuse, N. Y., T.I.S. Rept. No. R56EMH31; 1956.

A Technique for Reducing Errors in Permeability Measurements with Coils*

A recent note[1] gave a summary of the results of an investigation carried on at the National Bureau of Standards by Kostyshyn and Haas[2] for the purpose of studying the sources of error that are associated with the measurement of initial permeability using coils wound on toroidal samples of rectangular cross section. It was pointed out that various laboratories are, in general, using one of the following formulas for evaluating the permeability of a magnetic material.

$$\mu' = \frac{L_m}{L_a} \tag{1}$$

or

$$\mu' = \frac{L_m}{L_s} \tag{2}$$

where

μ' = real part of the relative initial complex permeability,
L_m = measured inductance of the coil wound on the magnetic sample,
L_a = the calculated inductance of an equivalent air core coil assuming a thin uniform current sheet,
L_s = measured value of inductance of an identical coil wound on a polystyrene core.

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* Received by the IRE, September 14, 1959.

[1] R. D. Harrington and R. C. Powell, "High-frequency magnetic permeability measurements using toroidal coils," Proc. IRE, vol. 46, p. 784; April, 1958.

[2] B. Kostyshyn and P. H. Haas, "Discussion of current-sheet approximations in reference to high-frequency magnetic measurements," *J. Res. Natl. Bur. Standards*, vol. 52, pp. 279–287; June, 1954.

Neither formula, as given above, can be expected to give a correct answer. Presumably, this is due to the fact that flux leakage effects and current sheet corrections are not considered in these equations. Various correction factors are usually applied to (1), and an attempt was made to evaluate the validity of these correction terms in the previously mentioned work at the National Bureau of Standards. However, one result that came out of this study, which has not been sufficiently emphasized, was that the errors in these measurements appeared to be largely independent of the magnitude of the permeability. This is apparently true even for a permeability of the order of unity which would be the case for the polystyrene core. It thus follows that errors in permeability measurements should subtract out if L_m and L_s are both measured and the results are substituted in an equation of the following form:

$$\mu' = \frac{L_m - L_s}{L_a} + 1. \tag{3}$$

This equation follows readily from (1) if we let ΔL be the error in the measured value of both L_m and L_s. Since ΔL is independent of permeability, we should write for the correct values of L_m and L_s:

$$L_m = \mu' L_a + \Delta L \tag{4}$$

and

$$L_s = L_a + \Delta L. \tag{5}$$

Subtraction of (5) from (4) will lead directly to (3).

In order to obtain a comparison of (1) through (3), a series of measurements were made at 50 kc using a Maxwell-type inductance bridge. A powdered iron core was used having a permeability of 7.05 as determined by a radio-frequency permeameter. The resulting data giving permeability as a function of number of turns used on the coil, are given in Fig. 1.

The increase in accuracy obtained using (3) is readily apparent. It was also observed that a curve similar to that resulting from (3) could be obtained by using (1) alone with corrections which account for finite wire size and departure of the wire from a uniform current sheet. On the other hand, the calculation of these corrections is usually quite tedious. As such, utilization of (3) offers a distinct advantage even though it does make it necessary to wind a separate coil on a polystyrene core. However, this must be done anyway whenever a measurement of magnetic loss is desired.

The above measurements were made using coils wound directly on the samples. Data are also given in Fig. 1 using (3) for the case where the sample has been reduced in size and a 0.05-inch layer of polystyrene lies between the core and the winding. The over-all cross section dimensions of the coil are the same as used in the previous measurements. A slight modification in L_a must, of course, be made in order to account for the reduced size of the core. As can be seen in the graph, removing the wire somewhat from the surface of the sample improves the accuracy of permeability measurements for a small number of turns. Presumably this is due to the creation of a more uniform flux inside the sample. The technique of separating the winding from the sample has been used in the past by other workers for obtaining more accurate loss measurements; however, the resulting improvement in real permeability apparently has not been adequately emphasized.

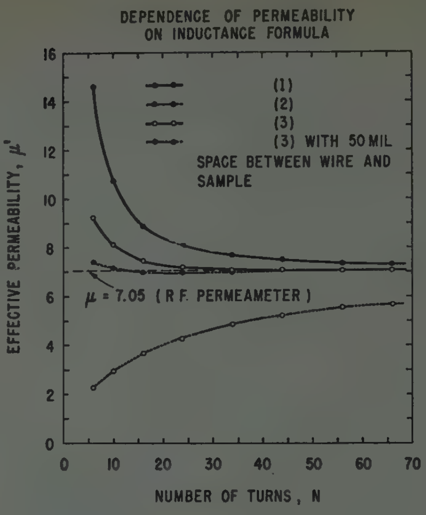

Fig. 1—Relationship between permeability, inductance formula, and number of turns on toroidal coil (inside coil dimensions: I.D. = 0.77 inch, O.D. = 1.37 inches, height = 0.30 inch, No. 36 wire).

The above results indicate that coils with a small number of turns can be constructed which can be opened for sample insertion and which will take advantage of the accuracy and convenience of inductance measurements obtained in connection with (3). Such coils have been described in the literature.[3] Similar work at the National Bureau of Standards has shown that coils of this type are satisfactory for precise measurements of both μ' and magnetic loss in the frequency range up to several mc.

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[3] I. Epelboin, "A study of metals with Hertzian waves with the aid of demountable winding permeameter," *L'Onde Electrique*, vol. 28, pp. 322–327; August–September, 1948.

Power Transmission via Radio Waves*

Introduction

The current revival of interest in the problem of transferring sizable amounts of power via radio link[1,2] has raised some questions as to the optimum antenna system which can be designed. In view of the fact that the antenna system represents the essence of radio power transmission, the main purpose of this letter is to indicate a design criterion which optimizes such an antenna system with due regard to the law of diminishing returns. The theory of coupled antennas has been presented in a previous paper[3] and consequently only the results, which have been adapted to this problem, are presented here.

Conventional Approach

Consider two coupled pencil beam antennas, one transmitting and one receiving. Free space propagation will be assumed as well as no depolarization loss. The receiving antenna is assumed to be conventional in that it concentrates the received energy onto a "terminal pair" as opposed to being a large absorbing mass through which the heat exchanger fluid passes.

The geometry is shown in Fig. 1.

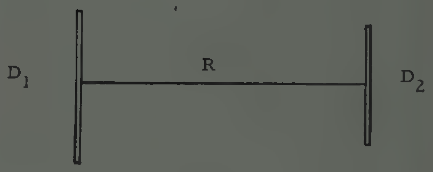

Fig. 1

In this problem, a constraint will be placed on the antennas; namely, $D_1 + D_2$ = minimum. This is a reasonable engineering as well as economic constraint and, in addition, allows for an optimum solution as opposed to an unrestricted maximum solution which would be devoid of all physical meaning.

The optimization condition may be stated several ways as follows:

$$\boxed{K_1 K_2 = K_{T_1} K_{T_2}} \tag{1}$$

or

$$\boxed{R_{T_1} R_{T_2} = R^2} \tag{2}$$

where

$$K_1 = \frac{\lambda R}{D_1^2}$$

$$K_2 = \frac{\lambda R}{D_2^2}$$

K_{T_1} = value of K_1 at $R = R_{T_1}$
K_{T_2} = value of K_2 at $R = R_{T_2}$
λ = wavelength
D = diameter or length of side of an antenna.

R_{T_1} and R_{T_2} are the Fresnel-Fraunhofer transition distances of apertures No. 1 and

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* Received by the IRE, September 14, 1959.

[1] M. T. Willinski, "Beamed electromagnetic power as a propulsion energy source," *J. Amer. Rocket Soc.*, vol. 29, pp. 601–603; August, 1959.

[2] "Raytheon microwave powered helicopter," *Time*, vol. 73, p. 55; May 25, 1959.

[3] R. W. Bickmore, "On focusing electromagnetic radiators," *Can. J. Phys.*, vol. 35, pp. 1292–1298; November, 1957.

No. 2, respectively, when focused at infinity.

Note that both equations are subject to the constraint $D_1+D_2=C_{\min}$. Note also that the value of K_T depends only on the aperture shape and distribution function. Typical values of K_T are as follows.[4]

Uniform square aperture	$K_T=1$	S.L. =13.2 db
Uniform circular aperture	$K_T=\frac{\pi}{4\sqrt{2}}$	S.L. =17.6 db
$(1-\rho^2)$ tapered[5] circular aperture	$K_T=\frac{\pi}{8}$	S.L. =24.6 db

An alternative form of the optimization relation is

$$\boxed{D_1D_2=\frac{\lambda R}{\sqrt{K_{T_1}K_{T_2}}}} \tag{3}$$

which, when combined with $D_1+D_2=C_{\min}$, yields

$$\boxed{\left.\begin{matrix}D_1\\ D_2\end{matrix}\right\}=\frac{1}{2}\left[C_{\min}\pm\sqrt{C_{\min}^2-\frac{4\lambda R}{\sqrt{K_{T_1}K_{T_2}}}}\right]}. \tag{4}$$

From (4) it is obvious that D has an imaginary component for

$$C_{\min}^2<\frac{4\lambda R}{\sqrt{K_{T_1}K_{T_2}}},$$

since both $C_{\min}^2$ and

$$\frac{4\lambda R}{\sqrt{K_{T_1}K_{T_2}}}$$

are always real and positive. The interpretation of this imaginary component of aperture[6] embraces what is known in antenna theory as "supergain." That is, for

$$C_{\min}<C_0=\left[\frac{4\lambda R}{\sqrt{K_{T_1}K_{T_2}}}\right]^{1/2},$$

the antennas must be conjugately supergained in order to be optimally coupled. Since antenna engineers know that supergain is practical only in theory due to high thermodynamic losses or, alternatively, astronomical values of Q, it may be concluded that values of $C_{\min}$ less than C_0 cannot be used for efficient *power* transmission. Note, however, that most "intelligence" transfer systems operate satisfactorily with values of $C_{\min}$ much less than C_0 without resorting to supergain. Operation in the latter mode is quite adequately described[7] by the so-called "one-way transmission equation" or "one-way radar equation." The final design equations are then

$$\boxed{C_{\min}=\left[\frac{4\lambda R}{\sqrt{K_{T_1}K_{T_2}}}\right]^{1/2}} \tag{5}$$

and as a consequence,

$$\boxed{D_1\equiv D_2=\tfrac{1}{2}C_{\min}} \quad \boxed{K_{T_1}\equiv K_{T_2}}. \tag{6}$$

Unfortunately, since the above system couples only the main beams down to about their respective half-power points, the transfer efficiency is fairly low. The value depends somewhat on the aperture distribution,[8] because this in turn controls the relative energies in the main beam and sidelobe complex of an antenna. Typical efficiencies are ideally about 45 per cent for the uniform circular aperture and about 72 per cent for the $(1-\rho^2)$ tapered aperture.

FOCUSED ANTENNAS

In a paper referred to in the Introduction,[3] the author established the concept of focused antennas as a means of exceeding the performance of conventional antennas when operated under near-zone conditions. Such operation requires a large ratio of aperture diameters but can provide coupling efficiencies substantially greater than the conventional antenna system. The reason is that each antenna will essentially "see" more than the main beam of the other antenna without experiencing the degradation in performance normally caused by Fresnel interference.

In this system, the smaller antenna may be conventional and should be of a size

$$\boxed{D_2=\sqrt{\frac{\lambda R}{K_{T_2}}}}. \tag{7}$$

The larger antenna, D_1, should be as large as practical and focused on the center of phase of D_2. The coupling efficiency is then approximately

$$\eta=\eta_1\eta_2,$$

where η_1 is the ratio of the energy in the portion of the Fraunhofer pattern of D_1 seen by D_2 to the total spacial energy and η_2 is the corresponding quantity for D_2. An ideal efficiency of 96 per cent can be obtained for $(1-\rho^2)$ tapered antennas when $D_1\approx 2\sqrt{\lambda R}$ and $D_2\approx 1.6\sqrt{\lambda R}$.

An optimum relation, in terms of diminishing returns, would be

$$\boxed{D_2=\sqrt{\frac{\lambda R}{K_{T_2}}}}$$

$$\boxed{D_1=A\sqrt{\lambda RK_{T_2}}} \quad \boxed{K_{T_1}=K_{T_2}}$$

where $A=D_2/\lambda$ {Null to Null beamwidth of D_2 in radians}

Distribution	A
Uniform Square	2.00
Uniform Circular	2.44
$(1-\rho^2)$ Tapered Circular	3.26

Note that the over-all circuit is a network problem[9] and that the foregoing applies only to the mutual coupling elements of this network.

Note also that power levels greater than the capacity of a single transmission circuit should be handled by multiple circuits operated in an *incoherent* (*e.g.*, different frequency) manner.

Finally, it should be mentioned that the total amount of waveguide in an identical pair of two-dimensional slot arrays, which are optimally coupled, is approximately *four times* the amount needed to run a direct transmission line between the two sites. Consequently, the reason for transferring power via radio waves must be more esthetic than simply the desire to transmit high frequency energy from A to B in the most economical manner.

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[4] R. W. Bickmore and R. C. Hansen, "Antenna power densities in the Fresnel region," PROC. IRE, to be published.

[5] S. Silver, "Antenna Theory and Design," M.I.T. Rad. Lab. Ser., McGraw-Hill Book Co., Inc., New York, N. Y., no. 12, p. 194–195.

[6] R. W. Bickmore, "A note on the effective aperture of electrically scanned arrays," IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-6, pp. 194–196; April, 1958.

[7] S. Silver, *op. cit.*, p. 4.

[8] R. C. Hansen, "Low noise antennas," *Microwave J.*, vol. 2, pp. 19–24; June 1959.

[9] S. Tetelbaum, "On the problem of efficient long-distance wireless power transmission," *J. Phys.* (*U.S.S.R.*), vol. 9, p. 505–514; June, 1945.

Improved High-Precision Quartz Oscillators Using Parallel Field Excitation*

Piezoelectric oscillators which have the form of plates and bars and vibrate in various modes of motion, *e.g.*, thickness modes, contour modes or extensional modes, generally can be excited by a field perpendicular to, or by a field parallel to, the major surfaces. Of particular interest is the behavior of quartz plates of the orientation $(YXl)\theta$ vibrating in the thickness-shear mode xy', *e.g.*, the AT or BT cut. The usual excitation of these cuts is achieved by a field perpendicular to the plate using two

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* Received by the IRE, September 18, 1959.

electrodes covering the major surfaces. The piezoelectric stress constant for excitation of this thickness-shear mode as function of the orientation angle θ is given by

$$e_\theta = e_{11}\cos^2\theta + e_{14}\cos\theta\sin\theta. \qquad (1)$$

The same thickness-shear mode can be excited by a field parallel to the plate,[1] and the corresponding piezoelectric stress constant is then

$$e_{\theta\psi} = (e_{11}\cos\theta\sin\theta + e_{14}\sin^2\theta)\sin\psi, \qquad (2)$$

where the azimuth angle ψ is taken from the X axis in the plane of the plate. For maximum excitation, the field must be parallel to the Z' axis ($\psi = 90°$). In order to provide a field parallel to the plate, the electrodes are arranged so that each electrode covers part of both major surfaces leaving a gap g parallel to the major surfaces of the plate.

Figs. 1 and 2 show laboratory models of quartz crystals of the *AT* cut vibrating at frequencies of 750 kc and 1000 kc, respectively, and using parallel field excitation. The data of the equivalent electric circuit depends on the width of the gap g. For a bevelled quartz crystal free of unwanted modes, as shown in Fig. 1, vibrating at 750 kc and having a diameter of 0.825 inch, Fig. 3 gives the motional inductance, L_1, Fig. 4 gives the parallel capacitance C_0, and Fig. 5 gives the capacitance ratio $r = C_0/C_1$ measured as function of the gap g. It has been found that an oscillator excited by a parallel field has a higher value for Q than an oscillator excited by a perpendicular field, provided that these crystals are mounted in a vacuum. The reason for the higher Q is a lower dielectric loss when using parallel field excitation instead of perpendicular field excitation. Because of the very high inductance L_1 and the high values for Q, quartz oscillators excited by a parallel field are perticularly suitable for application to high-precision frequency control. Using wider gaps, the center of the plate where the maximum mechanical stress occurs is not plated and therefore the aging caused by electrodes is reduced.

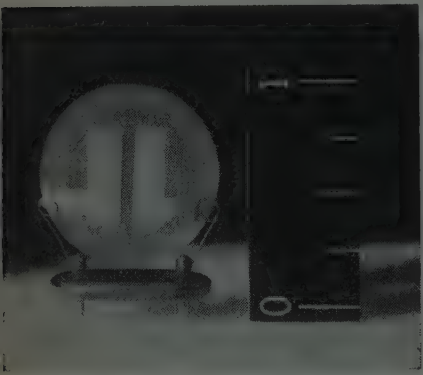

Fig. 1—Laboratory model of 750-kc quartz crystal excited by a parallel field.

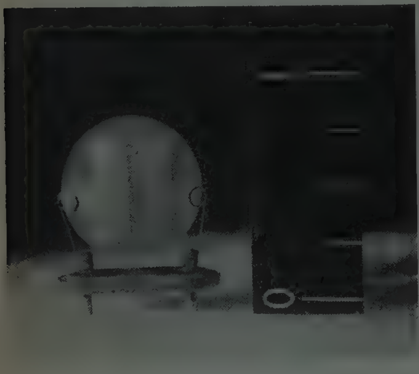

Fig. 2—Laboratory model of a 1000-kc quartz crystal excited by a parallel field.

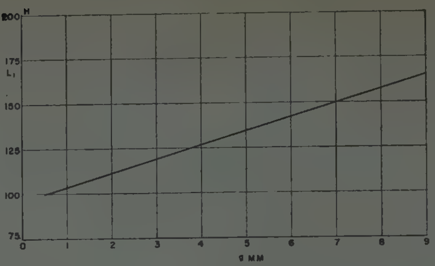

Fig. 3—Motional inductance L_1 of a 750-kc *AT* quartz oscillator excited by a parallel field as function of the gap g.

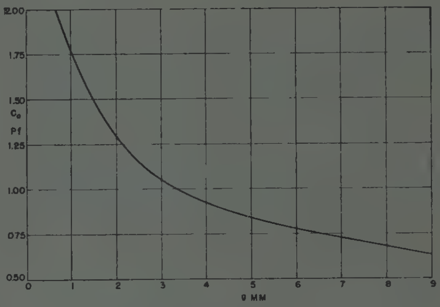

Fig. 4—Shunt capacitance C_0 of a 750-kc *AT* quartz crystal as function of the gap g.

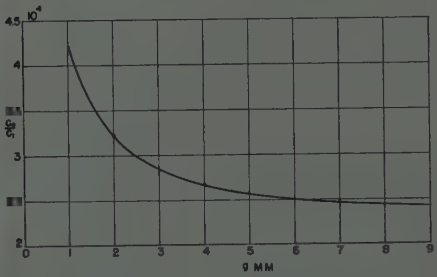

Fig. 5—Capacitance ratio $r = C_0/C_1$ of a 750-kc quartz crystal excited by a parallel field as function of the gap g.

Results of more detailed investigations will follow in due course.

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[1] R. Bechmann, "Über Dickenschwingungen piezoelektrischer Kristallplatten," *Arch., elek. Übertragung*, vol. 6, pp. 361–368; September, 1952; *Nachtrag*, vol. 7, pp. 354–356, July, 1953.
R. Bechmann, "Filterquarze im Bereich 7 bis 30 MHz," *Arch. elek. Übertragung*, vol. 13, pp. 90–93; February, 1959.

Spherical Aberration Due to Initial Path Angle and Lens Curvature in Aperture Electron Lenses*

The use of large area convergences in beam-type microwave tubes involves fairly large angles and curvatures in the electron guns. It is of interest to inquire into the effect of the spherical or cylindrical geometry on the strength of the anode lens, and into the proper application of the lens formula when an electron passes through the lens at a large angle to the optical axis.

Consider the spherical geometry typical of a Pierce gun as shown in Fig. 1. We make the usual thin-lens approximations by assuming that the radial electric force lines, which would normally fall on the portion of the sphere removed for the aperture, are undisturbed except for the sudden θ deflection in the spherical surface, as shown. The θ-momentum imparted to the electrons as they cross this surface leads to an expression for the lens action.[1]

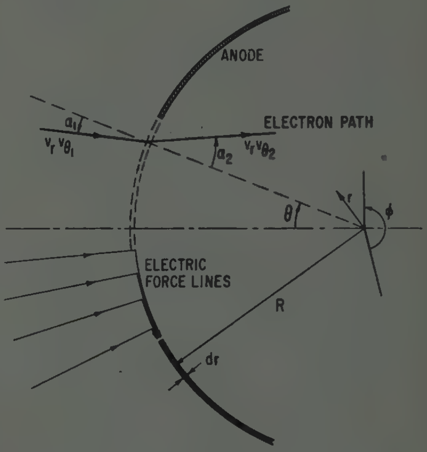

Fig. 1—Geometry of a spherical aperture lens.

We investigate the motion of an electron moving in a constant ϕ plane but having both r and θ components of velocity as it enters the lens. If V is the lens voltage these components of velocity are

$$v_r = \left(2\frac{e}{m}V\right)^{1/2}\cos\alpha_1$$

and

$$v_{\theta_1} = \left(2\frac{e}{m}V\right)^{1/2}\sin\alpha_1. \qquad (1)$$

The θ-directed force in the lens is found from the deflected radial electric flux, assuming that the field inside R is zero.

$$4\pi R^2\epsilon E_r\sin^2\theta/2 = -\epsilon E_\theta 2\pi R\sin\theta dr$$

or

$$E_\theta dr = -2RE_r\frac{\sin^2\theta/2}{\sin\theta}. \qquad (2)$$

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* Received by the IRE, September 18, 1959.

[1] L. A. Harris, "The electron optical action of an annular aperture lens," Proc. IRE, vol. 46, pp. 1655–1656; September, 1958.

For vanishingly small dr there is no change in the radial velocity v_r while the θ-velocity is increased by

$$dv_\theta = \frac{e}{m}\frac{E_\theta dr}{v_r}$$

$$= -\frac{\frac{e}{m}2RE_r\sin^2\theta/2}{\left(2\frac{e}{m}V\right)^{1/2}\cos\alpha_1\sin\theta}. \quad (3)$$

The new slope of the path with respect to a radius is, from (1) and (3),

$$\tan\alpha_2 = \frac{v_{\theta_2}}{v_r} = \tan\alpha_1 - \frac{RE_r\sin^2\theta/2}{V\cos^2\alpha_1\sin\theta}, \quad (4)$$

or the change in slope is

$$\tan\alpha_2 - \tan\alpha_1 = -\frac{RE_r}{V}\sec^2\alpha_1\frac{\sin^2\theta/2}{\sin\theta}. \quad (5)$$

If we call the distance from the polar axis $\rho = R\sin\theta$, then

$$\tan\alpha_2 - \tan\alpha_1$$
$$= \left(-\frac{\rho E_r}{4V}\right)\left(\frac{4\sin^2\theta/2}{\sin^2\theta}\right)(\sec^2\alpha_1). \quad (6)$$

In the corresponding cylindrical case, Fig. 1 represents a section through a cylinder slit along a line parallel to its axis which is perpendicular to the paper. The expression obtained from a similar analysis of this cylindrical case is

$$\tan\alpha_2 - \tan\alpha_1$$
$$= \left(-\frac{\rho E_r}{2V}\right)\left(\frac{\theta}{\sin\theta}\right)(\sec^2\alpha_1). \quad (7)$$

The first factor on the right-hand sides of each of these equations is the usual expression derived from the Davisson-Calbick lens formulas.[2] The second factors containing the θ-dependence show the influence of the geometry, which ordinarily is slight, but which may be significant in some cases. For the flat plane lens, θ becomes zero and both factors become 1. These factors are illustrated in Fig. 2.

The third factor, $\sec^2\alpha_1$, shown in Fig. 3, is the same in all geometries and shows the influence of the electron's entrance angle. It is interesting to examine more closely the meaning of this factor. Suppose we write the general expression

$$\tan\alpha_2 = \tan\alpha_1 + K\sec^2\alpha_1, \quad (8)$$

which can represent either (6) or (7). We now determine the angle α_2 by a Taylor expansion of the inverse tangent of the right-hand side of (8) about α_1.

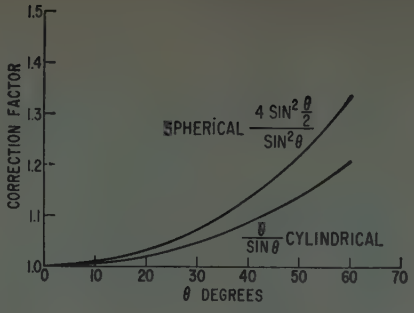

Fig. 2—Correction factor for change of slope due to lens curvature.

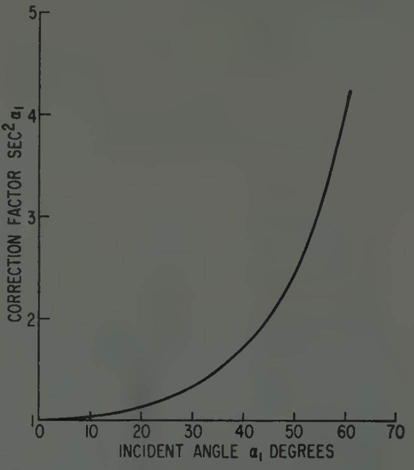

Fig. 3—Correction factor for change of slope due to initial angle of path.

$$\alpha_2 = \alpha_1 + K\sec^2\alpha_1\frac{d\tan^{-1}(\tan\alpha_1)}{d\tan\alpha_1}$$
$$+ \frac{K^2}{2}\sec^4\alpha_1\frac{d^2\tan^{-1}(\tan\alpha_1)}{d(\tan\alpha_1)^2} + \cdots \quad (9)$$

which becomes

$$\alpha_2 - \alpha_1 = K - K^2\tan\alpha_1 + \cdots. \quad (10)$$

Thus for reasonably small values of K (weak lenses), K gives the change in angle at the lens but not the change in slope of the electron trajectory.

Ideal imaging properties are implied in the usual lens formulas of light optics which are commonly applied in electron optics. Both modifying factors contained in (6) and (7) introduce positive spherical aberration, in effect, making the focal lengths functions of θ and α_1.

In the usual Pierce gun, where electrons converge along radii, the angle α_1 is ordinarily zero, though θ is not. Since we cannot know the precise surface along which the transverse flux may be considered to act, there is some ambiguity in the above development. Of course one expects aberrations in the focusing of wide-angle cones o electrons,[3] but the present treatment shoul clarify the nature of the influences of curvature and initial angle on the behavior of thi particular type of lens.

The author is grateful to his colleague in the General Electric Research Laborator for discussions of this note.

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[2] O. Klemperer, "Electron Optics," Cambridge University Press, Cambridge, Eng., pp. 62–63; 1953.

[3] O. Klemperer, *op. cit.*, pp. 12–14.

On the Origin of Negative Feedback*

Concerning the origin of negative feedback and the interesting application of it by Sargent, brought to light by Grote Reber,[1] there is a prior conception which I think merits a nomination for invention of negative feedback.

On January 9, 1923, a patent application (later to become Serial No. 1,723,719 was filed by Stuart Ballantine on a two-tube electrical communication circuit whic embodies a feedback network which is adjustable in phase so as to provide "an audi frequency bias voltage in phase with, o exactly opposite in phase to, the modulate radio frequency voltage—passing through t the detector." The primary purpose of thi circuit was to reduce the distortion produce by the detector in this reflexed two-tub radio receiver but the patent proceeds t state "that the invention is not limited to a radio receiving circuit of the type show since a correcting bias voltage of substantially the same wave form as an audio frequency wave or the modulated envelope o a radio frequency wave may be applied t an audion of other amplifying circuits fo the purpose of reducing or eliminating th distortion normally present in such a circuit."

Granting that this early picture is complicated by the RF-AF ramifications and th terminology, *e.g.*, audio frequency bias, neutralizing correction—I would still say tha negative feedback was here in 1923.

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* Received by the IRE, July 17, 1959.

[1] G. Reber, "Negative feedback a third of century ago," PROC. IRE, vol. 47, p. 1275; July, 195

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Morrel P. Bachynski (S'54–M'56–SM'58) was born on July 19, 1930, in Bienfait, Saskatchewan, Canada. He received the B.E. degree in engineering physics in 1952, the M.S. degree in 1953, both from the University of Saskatchewan, Saskatoon, and the Ph.D. degree from McGill University, Montreal, in 1955.

Until October 1955, as a member of the staff of the Eaton Electronics Research Laboratory (McGill University), he was engaged in investigations of aberrations in microwave lens systems. Since that time he has been with the RCA-Victor Research Laboratories, Montreal, Canada, concerned primarily with short-wave propagation and plasma physics problems. He is Associate Laboratories Director of the Microwave Laboratory.

Dr. Bachynski is a member of the Canadian Association of Physicists and Commission VI of the Canadian National Committee of URSI.

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Charles E. Cook (S'49–A'51–M'54–SM'56) was born on October 27, 1926, in New York, N. Y. He received the B.S. degree in physics from Harvard University, Cambridge, Mass., in 1949, and the M.E.E. degree from the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., in 1954.

From 1945 to 1946 he served in the U. S. Navy as an electronics technician. Thereafter, an electrical engineer, he specialized in pulse and electronic control circuits. He joined Sperry Gyroscope Co., Great Neck, N. Y., in 1951, assigned to radar research projects as an assistant project engineer. In 1953 he was advanced to project engineer and in 1956 to senior engineer. He was engaged in the basic investigation of pulse compression and coded transmission techniques, and has served as consultant in this field to other divisions of the company. In 1959 he was promoted to research engineer, where he is at present associated, with further development studies involving the use of pulse compression and correlated techniques applied to radar and communication systems.

Mr. Cook is a member of Sigma Xi.

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W. E. Danielson

W. E. Danielson was born in Fort Collins, Colo., on February 10, 1923. He received the B.S. degree in 1949, and the Ph.D. degree in physics in 1952, both at the California Institute of Technology, Pasadena. He joined the Bell Telephone Laboratories, Murray Hill, N. J., in 1952, where he engaged in microwave work involving noise studies, electron beam formation, traveling-wave and parametric amplifiers. In 1958 he became part of the military effort of the laboratories at Whippany, N. J., associated with research on pulse compression techniques, antennas, solid-state circuitry and military communications.

Dr. Danielson is a member of the American Physical Society, Sigma Xi and Tau Beta Pi.

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A. H. de Voogt

Anthonet H. de Voogt (M'49) was born in Amsterdam, The Netherlands, on May 1, 1892. A radio amateur since 1908, he obtained the wireless operator's certificate (class I) in 1914, and was employed in that capacity on ships of the Holland America line. In 1915 he graduated as an electrical engineer and entered The Netherlands PTT-Services, where he worked in the Long Lines Branch (Cables and Repeaters). After World War II he was appointed Head of all PTT Radio Services. When the Radio Services were subdivided in 1952, he became chief of the Ionosphere and Radio-Astronomy section. He installed the first radio telescope in The Netherlands at the Kootwijk radio station.

Mr. de Voogt attended the post-war Plenary Assemblies of URSI, IAU, CCIR, UGGI and CSAGI (International Geophysical Year), and initiated the establishment of geophysical stations at Hollandia, Netherlands New Guinea, Paramaribo, Surinam, and NERA (Nederhorst den Berg PTT-Receiving station).

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Tudor W. Johnston (M'59) was born on January 17, 1932, in Montreal, Canada. He received the B.S. degree in engineering physics from McGill University, Montreal, in 1953, and the Ph.D. degree from The University of Cambridge, England, in 1958. While at Trinity College, Cambridge, he investigated the dynamics of magnetically-focused electron beams from magnetically-shielded electron guns, including nonlaminar effects and ion phenomena.

He has participated in VHF FM relay development at the RCA-Victor Company, Ltd., Montreal, and on his return from England, joined the Microwave Laboratory of the RCA-Victor Research Laboratories in Montreal. He has collaborated in an analysis of the ion diode rocket and general electrical rocket characteristics, but his chief work is in electron beam and electromagnetic wave interaction with plasmas, and plasma physics in general.

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❖

M. Levy

Moises Levy was born in Concepcion, Panama, on April 8, 1930. He received the B.S. degree in chemistry and the M.S. degree in chemical engineering, both from the California Institute of Technology, Pasadena. He also did graduate work in physics at the University of California at Los Angeles, on a cooperative program with Hughes Products.

In 1953 he joined the laboratory of Specialty Resins Co., Lynwood, Calif., where he was involved in the preparation of alkyds and polyesters. In 1956 he became a member of the technical staff of the Semiconductor Division of Hughes Products, Newport Beach, Calif., engaging in the study of the influence of surface properties on operating device characteristics. In 1958 he accepted a teaching assistantship at the University of California at Los Angeles, where he is at present.

Mr. Levy is a member of the American Physical Society and Tau Beta Pi.

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H. L. McDowell

Hunter L. McDowell (S'48–A'49–M'55) was born in Washington, D. C., in 1927. He received the B.E.E. degree from Cornell University, Ithaca, N. Y., in 1948.

From 1948 to 1959 he was employed by The Bell Telephone Laboratories, Murray Hill, N. J., working mainly on the development of traveling-wave tube amplifiers, first for long haul radio relay systems and later for experimental millimeter wave systems. In August, 1959, he joined the staff of S.F.D. Laboratories in Union, N. J., where he is engaged in the development of crossed-field amplifiers.

E. T. Pierce

Edward T. Pierce was born on May 13, 1916, in Llandudno, Wales, Great Britain. In 1937 he received the B.S. degree in mathematics and in 1938 the B.S. degree in physics, both with first class honors, from the University of Wales. He received the Ph.D. degree from the University of Cambridge in 1950.

During the war Dr. Pierce held posts under the British Ministry of Supply and was particularly concerned with the development of aircraft armament. In 1946, he joined the faculty of the University of Cambridge, attached to the Solar Physics Observatory, where he did research work in the fields of atmospheric electricity, solar physics and the airglow. From 1950 to 1957, he was a University Teaching Officer at the Cavendish Laboratory, Cambridge, and was directly responsible for the research in the Meteorological Physics Section. This included work in atmospheric electricity, cloud physics, atmospherics and radio wave propagation, etc. From 1957 through 1958, he worked upon problems in atmospheric physics, gas discharges, and high voltage effects at Vickers Research Ltd., Weybridge, England, where he was Senior Scientist. Since January 1959, Dr. Pierce has been at AVCO RAD Division, Wilmington, Mass., as a Senior Staff Scientist, primarily dealing with topics in space and atmospheric physics.

Dr. Pierce is a member of Commission IV of URSI and a Fellow of the Royal Astronomical and Royal Meteorological Societies.

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E. D. Reed (A'48–M'55) was born on October 12, 1919, in Austria. He received the B.Sc. degree in electrical engineering from the University of London, Eng., and the M.S. and Ph.D. degrees from Columbia University, New York, N. Y.

He joined Bell Telephone Laboratories, Murray Hill, N. J., in 1947, where he has been engaged in the development of microwave and millimeter wave tubes and more recently in parametric amplifiers. He is presently associated with exploratory development of maser amplifiers and microwave ferrite devices.

❖

Frank Rosenblatt was born in New Rochelle, N. Y., on July 11, 1928. He received the B.A. degree in 1950, and the Ph.D. degree in experimental psychopathology in 1956, both from Cornell University, Ithaca, N. Y.

F. Rosenblatt

Since 1955 he has been on the staff of the Cornell Aeronautical Laboratory, in Buffalo, N. Y., originally as a research psychologist, and currently as head of the Cognitive Systems Section, which was created in 1959. He is also a lecturer in the Department of Psychology and Director of the Cognitive Systems Research Program at Cornell University. During the last five years he has been engaged primarily in the study of mathematical brain models, and the design of tactical control systems.

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R. A. Schmeltzer

Robert A. Schmeltzer (S'55–M'56) was born on May 20, 1933, in Brooklyn, N. Y. He received the B.S. degree in electrical engineering from the Cooper Union, New York, N. Y., in 1955, and the M.S. degree in electrical engineering from Stevens Institute of Technology, Hoboken, N. J., in 1958.

From 1955 to 1958 he was engaged in application engineering, first with the Electron Tube Division, and then the Semiconductor and Materials Division of the Radio Corporation of America, Somerville, N. J. in 1957 he served six months in the U. S. Army doing research and development work at the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. He presently is on leave of absence from RCA as the recipient of the David Sarnoff Fellowship for the second consecutive year, studying full time for the Doctor of Engineering Science degree at New York University, New York, N. Y.

Mr. Schmeltzer is a member of Eta Kappa Nu.

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B. Schwartz

Bertram Schwartz (M'56) was born in Brooklyn, N. Y. on November 1, 1924. He received the B.S. degree in chemistry from New York University, New York, in 1949, and has studied physical chemistry in the Graduate School of Columbia University, New York, N. Y.

After teaching chemistry for a short time in a New York city high school, he was employed by the Central Research Laboratories of Interchemical Corporation, New York, N. Y., to work on problems associated with butyl rubber compounds. In 1952 he joined Sylvania Electric Products, Tewanda, Pa., to work on the preparation of ultra-high-purity silicon. Since 1954 he has been with the Semiconductor Division of Hughes Products, Newport Beach, Calif., employed in the areas of surface characterization and chemical etching.

Mr. Schwartz is a member of RESA, the Electrochemical Society, and the American Chemical Society.

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I. P. Shkarofsky

I. P. Shkarofsky (M'58) was born in Montreal, Canada, on July 4, 1931. He received the B.S. degree with first class honors in physics and mathematics from McGill University, Montreal, in 1952. In 1953, he obtained the M.S. degree, conducting his research at the Eaton Electronics Research Laboratory, McGill University, in the fields of microwave optics and antennas. He then joined the microwave tube and noise group at the Eaton Electronics Research Laboratory, and received the Ph.D. degree in 1957 with a dissertation on modulated electron beams in space-charge-wave tubes and klystrons.

During summers, he has worked for the Defence Research Board and for Canadian Aviation Electronics Ltd., in electronics and radar research. After graduation, he joined the Research Laboratories of RCA-Victor Company, Ltd., Electromagnetic Division, where he is presently engaged in research on plasma and microwave physics.

Dr. Shkarofsky is an associate member of the Canadian Association of Physicists.

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J. T. Wallmark

J. Torkel Wallmark (A'48–M'55–SM'59) was born in Stockholm, Sweden, on June 4, 1919. He received the degrees of Civilingenjor in electrical engineering in 1944, Teknologie Licentiat in 1947, and Teknologie Doktor in 1953, from the Royal Institute of Technology, Stockholm.

From 1944 to 1945 he was a vacuum tube designer for the A.B. Standard Radiofabrik. From 1945 to 1953 he was with the Royal Institute of Technology as a research assistant on vacuum tube problems, while spending periods at the RCA Laboratories in Princeton, N. J., at the Elektrovarmeinstitutet and the Tekniska Forskningsradet, both in Stockholm, engaged in work on secondary emission tubes, semiconductors, and research administration, respectively. Since 1953 he has been with RCA Laboratories, Princeton, where he has been engaged in research on magnetrons, color television, and semiconductor devices, and most recently on integrated electronics.

1960 IRE INTERNATIONAL CONVENTION PROGRAM
Waldorf-Astoria Hotel, New York Coliseum, March 21–24, New York, N. Y.

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CONVENTION HIGHLIGHTS

Technical Program

A schedule of 54 technical sessions appears on the next page, followed by abstracts of the 258 papers to be presented.

Radio Engineering Show

This year's exhibition will again be held in the New York Coliseum at 59th St. and 8th Ave. A list of the 850 exhibitors and their products appears in "Whom and What to See at the Radio Engineering Show" in the advertising section of this issue.

Annual Meeting

Time: 10:30 A.M., Monday, March 21.
Place: Grand Ballroom, Waldorf-Astoria Hotel.
Speaker: Lloyd V. Berkner, President of the Associated Universities, Inc., "Can the Social Sciences Be Made Exact?"

The special features of this opening meeting of the convention will be of particular interest to all IRE members.

Annual IRE Banquet

Time: 6:45 P.M., Wednesday, March 23.
Place: Grand Ballroom, Waldorf-Astoria Hotel.

The Annual IRE Banquet is in many ways the climax, not only of the convention, but of the entire year. It is at this time that the leading contributors to the progress of our profession are annually singled out for recognition by the IRE. An outstanding program of nationally prominent guest speakers and IRE officers will include the presentation of six awards and recognition of the 76 newly elected Fellows of the IRE.

Seats are reserved on a "first come, first served" basis. Place your order now.

Cocktail Party

Time: 5:30–7:30 P.M., Monday, March 21.
Place: Grand Ballroom, Waldorf-Astoria Hotel.

Women's Program

An entertaining program of tours and shows has been arranged for the wives of members. Women's headquarters will be located in the Regency Suite on the fourth floor of the Waldorf.

SCHEDULE OF TECHNICAL SESSIONS

	WALDORF-ASTORIA HOTEL						NEW YORK COLISEUM		
	Starlight Roof	**Astor Gallery**	**Jade Room**	**Sert Room**	**Empire Room**	**Grand Ballroom**	**Faraday Hall**	**Marconi Hall**	**Morse Hall**
Monday March 21 2:30 P.M.–5:00 P.M.	*Session 1* CONTROL THEORY	*Session 2* THE BROOKHAVEN ALTERNATING-GRADIENT SYNCHROTRON; TRANSISTORIZED NUCLEAR INSTRUMENTATION	*Session 3* THE ENGINEER WRITES AND SPEAKS	*Session 4* RADIO FREQUENCY INTERFERENCE	*Session 5* ENGINEERING MANAGEMENT —I		*Session 6* ADVANCES IN AEROSPACE SUBSYSTEMS	*Session 7* PRODUCTION TECHNIQUES	*Session 8* ELECTRONIC DEVICES
Tuesday March 22 10:00 A.M.–12:30 P.M.	*Session 9* CONTROL APPLICATIONS	*Session 10* DIRECT CONVERSION	*Session 11* BROADCASTING —I	*Session 12* AUDIO		*Session 13** ENGINEERING MANAGEMENT —II	*Session 14* VARIED VIEWS OF MEDICAL ELECTRONICS	*Session 15* MODERN APPROACHES FOR IMPROVED AIR TRAFFIC MANAGEMENT	*Session 16* BROADENING DEVICE HORIZONS
Tuesday March 22 2:30 P.M.–5:00 P.M.	*Session 17* RADAR AND CODING THEORY	*Session 18* INDUSTRIAL ELECTRONIC INSTRUMENTATION	*Session 19* BROADCASTING —II	*Session 20* AUDIO AND BROADCAST AND TELEVISION RECEIVERS			*Session 21* THE HUMAN AS ORIGINATOR OF SIGNALS AND SCHEMES	*Session 22* DESIGN OF EQUIPMENT RELIABILITY	*Session 23* MICROWAVE TUBES
Tuesday March 22 8:00 P.M.–10:30 P.M.						*Session 24* *Panel:* ELECTRONICS—OUT OF THIS WORLD			
Wednesday March 23 10:00 A.M.–12:30 P.M.	*Session 25* DETECTION THEORY AND APPLICATIONS TO PHYSICS	*Session 26* BROADCAST AND TELEVISION RECEIVERS	*Session 27* ELECTRONIC COMPONENT PARTS	*Session 28* SPACE TELEMETRY		*Session 29** SEMINAR ON 1959 ITU GENEVA CONFERENCE	*Session 30* COMMUNICATION SYSTEMS DESIGN	*Session 31* ASPECTS OF COMPONENT RELIABILITY	*Session 32* MICROWAVE FILTERS
Wednesday March 23 2:30 P.M.–5:00 P.M.	*Session 33* ELECTRONIC COMPUTERS AND CIRCUIT THEORY: HOW EACH TECHNOLOGY CAN HELP THE OTHER	*Session 34* ULTRASONICS ENGINEERING—I	*Session 35* COMPONENT PARTS	*Session 36* STEREOPHONIC SOUND REPRODUCTION			*Session 37* COMMUNICATION SYSTEM TECHNIQUES	*Session 38* ANTENNA PATTERN SYNTHESIS	*Session 39* MICROWAVE INTERACTION WITH MATTER
Thursday March 24 10:00 A.M.–12:30 P.M.	*Session 40* ADAPTIVE NETWORKS	*Session 41* CIRCUIT THEORY: CURRENT CONTRIBUTIONS	*Session 42* ULTRASONICS ENGINEERING —II	*Session 43* EQUIPMENT AND SYSTEMS	*Session 44* SATELLITE COMMUNICATIONS		*Session 45* HUMAN FACTORS IN ELECTRONICS	*Session 46* SCANNING ANTENNA ARRAYS	*Session 47* MAGNETIC RECORDING
Thursday March 24 2:30 P.M.–5:00 P.M.	*Session 48* ELECTRONIC COMPUTERS	*Session 49* SYMPOSIUM ON A DECADE OF PROGRESS IN NETWORK THEORY	*Session 50* SPACE ELECTRONICS	*Session 51* CHECK-OUT INSTRUMENTATION AND CIRCUITRY			*Session 52* VEHICULAR COMMUNICATIONS	*Session 53* ANTENNA AND PROPAGATION PROBLEMS	*Session 54* WAVEFORM ANALYSIS AND RANDOM VIBRATION

* Sessions terminate at 12:00 Noon.

ABSTRACTS OF TECHNICAL PAPERS

SESSION 1*

Mon. **2:30–5:00 P.M.**

Waldorf-Astoria
Starlight Roof

CONTROL THEORY

Chairman: John C. Lozier,
Bell Telephone Labs., Inc.,
Whippany, N. J.

1.1. Incremental Phase Plane Analysis of Nonlinear Sampled Systems

J. A. Aseltine and R. A. Nesbit,
Space Technology Labs., Inc.,
Los Angeles, Calif.

An analysis technique for nonlinear sampled data systems is developed, using the incremental phase plane. This method is analogous to the phase-plane method for continuous systems. A sampled data system with saturation is analyzed to demonstrate the use of the incremental phase plane in system analysis. Path tangent curves are introduced which allow the graphical solution of systems with general types of nonlinearities. A difference equation analog of van der Pol's equation is solved using the path tangent curves.

1.2. On the Existence and Uniqueness of the Optimal Multivariable Systems Synthesis

Mihajlo D. Mesarović, *Case Inst. Tech., Cleveland, Ohio*

The possibilities of achieving a totally optimal performance in multivariable systems have been considered for filter and control-type problems. For a functional performance criterion and a linear system, the derived optimizing equations do not uniquely define an optimal system. Additional specifications are necessary for a complete determination of the system. The various types of synthesis could be characterized by these additional specifications. For nonlinear systems in general the derived equations, based on performance criteria, uniquely define the optimal system. Nonlinear multivariable systems could be classified according to completeness in determining an optimal system using a certain type of performance criterion. For a set of random inputs the performance criteria are expressed as a mean over some function of the outputs. In such a case minimizing equations cannot in general be satisfied by the characteristic functions of the system to be synthesized. The relatively optimal systems can be, however, uniquely defined.

1.3. On Optimal and Suboptimal Policies in the Choice of Control Forces for Final-Value Systems

Masanao Aoki, *Dept. of Engrg.,*
University of California,
Los Angeles, Calif.

Some discrete final-value systems are formulated as stochastic multistage decision processes.

A functional equation is set up and solved to obtain an optimal sequence of control forces (henceforth referred to as an optimal policy) for a given performance index.

The procedure is illustrated for the case of the usual minimization of the mean-square of the final error, with discussions of analytic and computational techniques.

A simpler yet near-optimal policy is conjectured and performances of final-value systems with the optimal and the suboptimal policies are compared by the Monte Carlo method.

An approximate analysis of the system behavior resulting from the suboptimal policy is also presented.

1.4. A Study of Asynchronously Excited Oscillations in Nonlinear Control Systems

O. I. Elgerd, *Dept. of Elec. Engrg.,*
University of Florida,
Gainesville, Fla.

This study was initiated as an effort to explain certain oscillatory phenomena observed in an aircraft and weapon control system operated in a particular mode. The oscillations in question were of the undamped limit-cycle type and their presence could very clearly be correlated with the degree of noise corruption of the signals.

It is demonstrated in this paper that certain types of nonlinear systems, although inherently stable, may be driven into oscillatory modes not only by random signals but also by any high-frequency periodic or nonperiodic signal possessing a certain energy content. It is of interest to note that the tendency for hunting and also the hunt frequency usually are completely independent of the frequency of the excitation signal, *i.e.*, the phenomenon is of asynchronous nature.

A general theory, the validity of which has been tested by both analog and digital means, is presented and utilized to demonstrate how this phenomenon may be predicted from information on circuit data.

1.5. On the Optimum Synthesis of Sampled Data Multipole Filters with Random and Nonrandom Inputs

H. S. Hsieh and C. T. Leondes,
Dept. of Engrg., University of
California, Los Angeles, Calif.

This paper considers the synthesis of optimum sampled data multipole filters with n inputs and m outputs. The signal portion of the input will consist of a stationary random component and a nonrandom component which is assumed to be polynomial with unknown coefficients but known maximum order. Each signal is corrupted by stationary random noise. The filter under investigation is linear, time invariant, and with finite memory.

The design criterion is to specify the weighting functions of the filter so that the system error, which is defined as the difference between the actual and ideal outputs, has zero ensemble mean and the system ensemble mean square error is minimum. The weighting functions thus obtained will have, in general, abrupt jumps at the sampling instants, but they are continuous within the sampling intervals.

SESSION 2*

Mon. **2:30–5:00 P.M.**

Waldorf-Astoria
Astor Gallery

THE BROOKHAVEN ALTERNATING-GRADIENT SYNCHROTRON; TRANSISTORIZED NUCLEAR INSTRUMENTATION

Chairman: Richard F. Shea,
General Electric Co.,
Schenectady, N. Y.

2.1. The Brookhaven Alternating-Gradient Synchrotron

Part I—Alternating Gradient Synchroton, J. P. Blewett, *Brookhaven Natl. Lab., Upton, N. Y.*

Part II—The Linear Accelerator Injector for the AGS, S. D. Giordano, *Brookhaven Natl. Lab., Upton, N. Y.*

Part III—Radio-Frequency Accelerating System for the AGS, M. Plotkin, *Brookhaven Natl. Lab., Upton, N. Y.*

The alternating-gradient synchrotron at Brookhaven National Laboratory is being prepared for initial operating. The 30-billion electron volts, $30-million proton accelerator will be the first American machine to reach this energy. These three papers present some of the principles of design and the details of construction of the project.

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* Sponsored by the Professional Group on Automatic Control. To be published in Part 4 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Nuclear Science. To be published in Part 9 of the 1960 IRE International Convention Record.

2.2. Transistorized Radiation Monitoring Equipment

J. J. HENRY, *Union Carbide Nuclear Co., Oak Ridge, Tenn.*

An integrated monitoring system is described which features modular hermetically sealed construction and which operates from 115-volts, 60-cycle ac power. It consists of a completely transistorized linear preamplifier, amplifier, discriminator, and count rate meter. The amplifier is extremely stable and has a band pass greater than 5 megacycles, linearity of 0.5 per cent and excellent overload characteristics. The discriminator is nonsaturating and the rate meter features a diode switch, constant current, metering circuit. The entire system is capable of operating linearly at uniform repetition rates up to 500 kc. A variable low impedance output is provided for continuous potentiometric recording.

2.3. A Sensitive Parametric Modulator for DC Measurements

R. R. HOGE, *Bendix Aviation Corp., Detroit, Mich.*

This paper concerns a high-impedance semiconductor modulator for amplification of signal currents at levels which previously have required the use of electrometer tubes. An input threshold of 5×10^{-14} watts at 10^{-12} amperes is observed, and substantial signal power gain is provided by the modulator. The modulator is basically an ac Wheatstone bridge in which two arms are silicon capacitor diodes. Input signals modify the capacitance of the depletion region in the diodes and control the (un)balance of the Wheatstone bridge. Initial balancing adjustments are simple and permanent, and are limited to one or two components. Typical applications in transistorized nuclear instrumentation are indicated.

2.4. Semiconductor Synchronous Clamp for Millivolt Signal Levels

A. J. KOLL, E. BLECKNER, AND O. C. SRYGLEY, *Aero Geo Astro Corp., Alexandria, Va.*

Semiconductor clamp and detecting circuits of the conventional type are subject to serious inaccuracies when applied in the millivolt range. This nonlinearity in operation is caused by the barrier potential which is inherent in semiconductor devices.

The purpose of the circuit described herein is to provide a method of accurately clamping pulses in the millivolt range to any desired dc level. It is also useful for detecting pulse amplitudes in the millivolt level and for storing this detected amplitude in a memory or learning time constant.

The basic circuit employs a bridge with two forward biased diodes and two Zener diodes. The diodes are arranged so that a voltage pulse applied to the bridge provides high conductivity to pass the low-level signal. When the pulse is removed from the bridge, the Zener characteristic prevents leakage back through the bridge element. This circuit operates well with low millivolt pulses over an extremely wide temperature range and it successfully meets a wide variety of extreme environmental conditions.

SESSION 3*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria
Jade Room

THE ENGINEER WRITES AND SPEAKS

Chairman: CHESTER W. SALL, *RCA, Camden, N. J.*

3.1. How to Edit Your Own Papers

ELEANOR M. MCELWEE, *RCA, Harrison, N. J.*

This paper proposes to begin where most "how-to-write" articles end, *i.e.*, to show how engineers can improve their reports, papers, and proposals *after they write them.* Editing is shown to be simply a critical appraisal of written material to make sure that it says exactly what the writer intends and will not be misinterpreted. Several common writing faults which tend to obscure meaning are analyzed, and a "do-it-yourself" approach is described for recognizing and correcting them in a preliminary draft. The topics covered include organization of material, testing for relevancy and sufficiency by means of an outline, paragraphing, function of subheads, a diagrammatic method of sentence editing, the logical basis for rules of grammar and punctuation, use of abbreviations and symbols, and handling of forumulas, tables, and illustrations. A "check list" of major items is included for use by engineers in the editing of their own papers, reports, or proposals.

3.2. Basic Concepts of Increased Effectiveness in Oral Presentations

IRVING J. FONG, *Remington Rand Univac, Div. of Sperry Rand Corp., St. Paul, Minn.*

The danger of our present system of information documentation and retrieval collasping under its own weight has been partly alleviated by the creation of auto-abstracts, produced entirely by machine techniques. Computers now can read from a document directly, and with machine-generated thought processes, produce abstracts and indexes to save reader-time and effort.

The human creator, in teaching the machine to simulate his own patterns of learning and thought processes, in the field of scientific communication has neglected his own natural medium of communication to an audience, that is, the spoken language or oral presentation. A return to basic concepts that could increase the effectiveness of verbal presentations of technical papers is given. This is intended to balance the progress made by recent machines in producing abstracts, since an oral presentation is in effect an amplified abstract, whose purpose also is to facilitate the selection and utilization of useful information.

3.3. New Horizons in Scientific Information Preparation

N. J. SMITH, *IBM Corp., Kingston, N. Y.*

The overwhelming volume of scientific documentation has almost succeeded in making the retrieval of information an impossibility. Three International Conferences on Scientific Information have been held to define problems of information retrieval and to investigate automated methods of solution.

As a result, the next phase of study will surely be a reappraisal of the methods and techniques of preparing scientific reports and documentation. The present method of composing reports and documentation by writing is essentially only a mode of information storage. In the final analysis, the efficiency of retrieval is determined by the method of information preparation, storage, and transfer. And since the optimum solution of the retrieval problem will lead inevitably to a study of the information preparation and storage, it is, indeed, the time for Engineer Writers to examine the basic concepts of language as a science and not as an art. New formats for idea arrangement and connotation control are even now being developed. These formats lend themselves to automated techniques of storage and, hence, to automated research and retrieval.

This paper discusses the status of automated retrieval systems and the problems and possibilities of the new techniques of information preparation. It describes the disciplines involved and discusses the present state of the art. It suggests areas of investigation for those who must be ready for these new requirements for the preparation of scientific information.

3.4. The Paper Reader at Conventions Will Soon Be Obsolete!

J. O. REECE, *Texas Instruments Inc., Dallas, Tex.*

For many years the trend of authors presenting technical papers at conventions and symposiums has been to read the paper from beginning to end. At recent technical conventions, however, the paper reader has been outlawed.

Most speakers at conventions read their speeches in such a deadly monotone that it actually lulls the listeners to sleep. The reader of a speech seems to lose all contact with the audience. The paper reader somehow fails to realize that he owes a responsibility to the audience. That responsibility is to make his speech interesting to everyone in the room so that the entire audience wants to hear what he is saying instead of having the feeling of being forced to listen to him.

This paper will describe why technical conventions in the near future will be operating by a new format, that of an orally presented paper, and why the paper reader will soon be obsolete.

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* Sponsored by the Professional Group on Engineering Writing and Speech. To be published in Part 10 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 4*

Mon. **2:30–5:00 P.M.**

Waldorf-Astoria
Sert Room

RADIO FREQUENCY INTERFERENCE

Chairman: Ralph M. Showers,
University of Pennsylvania,
Philadelphia, Pa.

4.1. Simulation Tests on an Interference Rejection Antenna System

W. D. White and C. O. Ball,
Airborne Instruments Lab.,
Mineola, N. Y.

The antenna investigated consists of three identical receptor elements spaced in a suitable configuration. They are so arranged that at the output terminals the desired signal can be represented by three identical phasors. Due to the physical separation however, an interference signal will be represented by three phasors having identical lengths but different phase angles. The resultant of signal plus interference will thus produce three phasors lying on the circumference of a circle. A computer which is capable of finding the center of this circle will then deliver an output signal uncontaminated by the interference.

The performance of the system is limited by the accuracy with which the three receptor elements can be made identical and by the effects of receiver noise. To investigate the latter limitation, a digital computation program was set up to simulate the operation of the system. The results indicate that if advantage is taken of the fact that the relative jammer phases are likely to be slowly varying, then, with reasonable separation of the interference phasor, the residual interference signal can be reduced below the level of receiver noise.

4.2. Computer Simulation of Signal Environments

W. G. James, *American Machine & Foundry Co., Alexandria, Va.*

As an aid to designers, a digital computer simulation program which can determine the signal environment resulting from a large deployment of electromagnetic emitters has been developed for use with the IBM 704 computer. The program provides realistic simulation of such emitter characteristics as antenna gain patterns and scanning cycles and of such propagation phenomena as atmospheric absorption and tropospheric refraction. A deployment of some 5000 emitters including a variety of some 100 types has been simulated. The program design permits extensive expansion of the number of emitters and emitter types in the simulated environment.

4.3. Wiring of Data Systems for Minimum Noise

J. V. White, *Beckman/Systems Div.,*
Anaheim, Calif.

Noise sources due to undesired coupling of circuits in a data system can be minimized by proper wiring. Construction of a system central ground, which avoids ground-resistance coupling, is described. To eliminate the remaining common-resistance coupling, this construction is extended to include all system nodes. Proper location of the ground and nodes permits wiring all noise-sensitive circuits with twisted cable, minimizing coupling through mutual inductance. Proper shielding for protection from electrostatic interference is simplified. A set of explicit wiring rules, which implement this method, is given. Examples of the application of these rules are included.

4.4. Receiver Analysis for Interference Prediction Purposes

D. C. Ports and C. R. Miller,
Jansky & Bailey, Washington,
D. C.; and J. Savage,
Rome Air Dev. Center,
Griffiss AFB, N. Y.

A method will be presented to describe a means of evaluating receiver behavior for a degree of susceptibility to various types of undesired signals. To determine acceptable levels of RF input energy, it is necessary first to examine signals at the receiver output terminals to establish a required level and quality of desired intelligence. Examination proceeds from output to RF input on a function-by-function basis to determine the modifying effects caused by pertinent characteristics of RF, IF, and detector circuits, on the intelligence as it passes through the receiver. Results are combined to produce an expression for a transfer function. Intelligibility adjustments are obtained from this to deduce the degree of control exerted by the portions of the receiver, and this enables the development of a technique for prediction of level of interference to be anticipated.

4.5. Electromagnetic Interference and Vulnerability Reduction

John J. Egli, *U. S. Army Signal*
R & D Lab., Fort Monmouth,
N. J.

Interference and vulnerability, the first signifying a mutual or unintentional interference, and the second signifying an intentional interference, are omnipresent disturbances which must be reduced to permit tactics of the military to be consummated without extraneous impairment.

In the research and development area of electromagnetic interference and vulnerability reduction, three important phases are essential to achieve reduction: 1) theoretical analysis, 2) design criteria, and 3) instrumentation and measurements. A research and development organization capable of handling these three important phases has been established at the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J.

While environment testing is a requirement for a well-integrated reduction program and will be provided as a facility at the U. S. Army Electronic Proving Ground, Fort Huachuca, Ariz., this facility will not be a subject for discussion in this paper.

4.6. Fire Fighting or Fire Prevention

L. A. Yarbrough and J. W.
Worthington, Jr., *Hdqrs.*
GEEIA, Griffiss AFB,
N. Y.

The subject of reduction or elimination of interference to Communications-Electronics equipment, facilities, or systems has been the topic of many papers, conferences, meetings symposia, and other get-togethers. Many techniques, in theory, are known to reduce or eliminate interference. Unfortunately, not many "black boxes" are available to implement the theoretical solutions.

This paper will present the aggressive twofold program to prevent or reduce interference being implemented by the USAF Ground Electronics Engineering Installation Agency (GEEIA). Methods of fire prevention discussed will include advance planning and adequate pre-engineering effort, proper siting, equipment or system interference specifications, and installation techniques. Details of GEEIA's "fire fighting" capability, consisting of contractor furnished teams, plus an "in-house" capability will be discussed. Future plans to reduce or prevent interference to USAF CE systems will be discussed.

SESSION 5*

Mon. **2:30–5:00 P.M.**

Waldorf-Astoria
Empire Room

ENGINEERING MANAGEMENT—I

Chairman: H. M. O'Bryan,
Sylvania Electric Products,
Inc., New York, N. Y.

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* Sponsored by the Professional Group on Radio Frequency Interference. To be published in Part 8 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Engineering Management. To be published in Part 10 of the 1960 IRE International Convention Record.

5.1. Management and the Employee-Owned Concept of Young R and D Growth Firms

D. M. Kruchko, *Aero Geo Astro Corp., Alexandria, Va.*

This paper presents a discussion of the problems and challenges of relatively new electronic R and D firms where relatively youthful technical personnel are subject to a new way of life surrounded by overhead cost distribution, operating costs, amortizations, depreciations, net worth, etc. It describes the unique features of an employee-owned firm where over 90 per cent of the employees are also stockholders.

The rewards, tangible and intangible, of being entrepreneurs in a society of corporate giants are detailed. In addition, a presentation is made of the advantage of flexibility and individual enthusiasm growing out of the employee-owner concept.

The paper concludes with a detailed presentation of the advantages the small R and D firms offer customers, both Government and commercial.

5.2. An Engineering Management View of the Maintainability Problem

M. J. Marcus, *IBM Corp., Owego, N. Y.*

Management can take an important hand in the increase of product maintainability by recognizing the management factors in development engineering which bear directly on the eventual maintenance problems of the customer.

The maintainability of a system is usually evaluated only after the system has been placed in operation. It is then that customer and contractor maintenance personnel point out maintainability design deficiencies and expensive retrofit begins. This feedback loop must be shortened by detailing the implications of design decisions for system maintainability at the time development decisions are made.

Management techniques for insuring this shortened feedback loop on maintainability are described and discussed.

5.3. Engineering Management for Creative Appraisal of New Ideas—The Secret Weapon for Technical Progress?

William H. Beaubien, *General Electric Co., Utica, N. Y.*

Effective appraisal of ideas is probably more important than conceiving them. It is very challenging in engineering management to exercise techniques for idea appraisals that can effectively select and promote the best ones without unwittingly eliminating some that may later emerge from other competitive sources with a tremendous scientific or technical impact. This usually results from man's inherent tendency to look for what is wrong rather than assuming an attitude of "How can we make it work?"

Planned engineering management programs employing creative idea appraisal techniques are shown to result in dramatic increases in new products, technologies, services, and operating practices. The widely varying degree of technological impact that has resulted indicates the universal nature of the application possibilities of this new management tool.

5.4. How to Produce Reliable Products at a Profit

C. W. Watt, *Raytheon Co., Waltham, Mass.*

Active and rapid feedback channels from detecting points to action points in the organization are essential if an over-all manufacturing-engineering system is to produce reliable and profit-making products. That the concept of negative feedback is a valid one organizationally can be seen by observing its operation in manufacturing, where it is realized as the quality control function. A similar monitoring function should exist formally in engineering; and when it does it can lead to better performance of the engineering job. One way to establish such a function is through the medium of the design review, which can be effected in most cases with no increase of personnel. As a corollary, the specialists in the engineering organization can be most effectively used when they, taking a team approach, can provide a balanced consulting service to the designers with whom they work, and also participate actively in design reviews.

5.5. Concepts of Capital Financing for Electronic Companies

R. T. Silberman, *Electronics Capital Corp., San Diego, Calif.*

During the last decade the nearly ten-fold expansion of the electronics industry has brought with it a myriad of different approaches to the solution of working capital problems. These principally have included private and public equity financing, Government "V" loan credit, short-term bank credit, and accounts receivable financing and vendor financing in the form of delayed settlement of accounts payable. Internal cash flow naturally has been generated from depreciation and profits—where, in fact, the operations have been successfully managed.

It is now possible to look back and bring into proper focus the consequences of each method of financing and how these methods have affected the company growth, market position, and the capital appreciation of the company founders and stockholders. The lessons of our past financial activities define objectives for future financing of existing and new electronic enterprises. The heavy hand of direct Government contracting has specific influence in determining the optimum financial plan. The prospect of continuing inflation, high interest rates, and a generally controlled economic environment make certain forms of debt financing most attractive when in proper balance to earned surplus and equity.

Special legislative action during the past years in the creation of Small Business Investment Companies provides another vehicle for capital expansion in the next decade. Factors for determining the true cost of financing when balanced against growth rate, market appreciation, and owner equity are discussed.

SESSION 6*

Mon. 2:30–5:00 P.M.

Coliseum
Faraday Hall

ADVANCES IN AEROSPACE SUBSYSTEMS

Chairman: D. G. C. Luck, *RCA, Princeton, N. J.*

6.1. Range Ambiguity Resolution in High PRF Radar

Norman S. Potter, *The W. L. Maxson Corp., New York, N. Y.*

The origins of high pulse recurrence rates in radar and the fundamental means of resolving the resultant ambiguities are quantitatively discussed. An analytical study is conducted of the information requirements for the determination of target range as opposed to detection alone. A statistical model of the detection and ambiguity resolution process is constructed for several generalized radar-computer system configurations. A new general theory is developed and applied to determine quantitatively the relationship between system memory and range resolution for information handling schemes that bracket all ambiguity resolution techniques.

For purposes of demonstration, the theory is applied to range quantized systems, and appropriate digital techniques are developed for the processing of multiple PRF coded data. The required radar signal modulation is functionally related to operational and system parameters. Eclipsing losses and the degradation of the efficiency of the range ambiguity resolution subprogram due to the simultaneous presence of multiple objects in the beamwidth are statistically investigated and signal modulation methods that minimize these problems are developed.

6.2. An Ion Altimeter for Pressure-Altitude Measurements

G. V. Zito, *Bendix Aviation Corp., Teterboro, N. J.*

A ruggedized, cold cathode radiation-type ionization air density gauge for pressure-altitude measurements is described together with the front-end circuitry required for instrumentation. Typical applications include the static pressure sensor channel of hypervelocity machmeters and altimeters where continuous indication is desirable and in air data computer systems for military and commercial aircraft. The hysteresis and position sensitivity of diaphragm-type sensors are largely absent in this class of device. Historical background on the development of extreme altitude sensors, and pertinent data on calibration procedures and sensor compensation are also included.

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* Sponsored by the Professional Group on Aeronautical and Navigational Electronics. To be published in Part 8 of the 1960 IRE International Convention Record.

6.3. The Nature of Astro Doppler Velocity Measurement

JOHN E. ABATE, *Kearfott Co., Inc., Clifton, N. J.*

Astro Doppler velocity measurement for space vehicle navigation requires the use of electro-optical systems capable of measuring a small incremental change in the wavelength of propagated stellar energy. Such systems provide velocity data whose character and limitations are a function of the star's radiation as well as the system instrumentation. This paper discusses the velocity data, their character and limitations; and the Doppler velocity systems, their capabilities, limitations, and instrumentation.

6.4. Generation of Artificial Electronic Displays, with Application to Integrated Flight Instrumentation

G. H. BALDING, *Kaiser Industries, Palo Alto, Calif.*, AND C. SÜSSKIND, *University of California, Berkeley, Calif.*

A novel method is described by which complex electronic signals are generated, dynamically varied, mixed, and presented on a standard video (raster-scan) display, without the use of vidicon or similar camera devices. The method is applied to the generation of a "contact-analog" display that provides a stylized representation of the real world to the pilot of an aircraft. This integrated display, which varies continuously as the speed, altitude, or attitude of the aircraft changes, also contains a "flight-path" representation that enables the pilot to maintain a prescribed path.

6.5. The Synchro-Magnetic Approach and Terminal Landing System for Aircraft

ROSS GUNN, *The American University, Washington, D. C.*

A reliable system for the guidance and control of aircraft near airports, throughout the period of approach, landing, and taxiing, has been developed.

The system employs a guide cable, excited by alternating current, which is laid, buried, or carried on poles along the projection of a preselected straight or curved flight path. The magnetic field pattern established by the current is sensed on the aircraft as it flies more or less parallel to the guide cable up to altitudes of more than 2000 feet. The magnetic pattern permits the simultaneous and unambiguous determination of the approximate altitude, the horizontal position of the aircraft with respect to the guide cable, the angle of yaw, and the direction of the flight along the cable. The response of all elements increases regularly as the touchdown point is approached, so that precision control of the flight path by automatic devices is entirely practicable.

Equipment is available that works successfully anywhere within 2000 feet of the guide cable. Greater ranges are accessible. Basic principles and detailed measurements of performance on a one-tenth scale landing range will be presented. The new system has many valuable operating features including simplicity and great reliability.

SESSION 7*

Mon. **2:30–5:00 P.M.**

Coliseum
Marconi Hall

PRODUCTION TECHNIQUES

Chairman: ROBERT L. SWIGGETT, *Photocircuits Corp., Glen Cove, N. Y.*

7.1. Fabrication and Interconnection of Microcircuits Applicable to Data Processing Equipment

J. E. RICHARDSON AND J. W. BURKIG, *Hughes Aircraft Co., Culver City, Calif.*

The feasibility of microminiaturizing data processing equipment is discussed. The following topics are covered:

1) The fabrication of circuit elements with attention to controlling parameters to predetermined values within given tolerances.
2) The problem of interconnection of individual circuit elements into circuits and the interconnection of aggregates of circuits into assemblies.
3) Problems of heat density, maintainability and reliability.

The discussion of application to data processing equipment is intended as a specific example. The discussion is equally applicable to the general field of microminiaturizing electronic equipment.

7.2. Ultrasonic Welding of Electronic Components

W. C. POTTHOFF, C. F. DEPRISCO, AND W. N. ROSENBERG, *Aeroprojects Inc., West Chester, Pa.*

A brief review of the ultrasonic welding process is given, with brief description of spot-type, continuous-seam, and ring-type welding equipment of interest to the electronics industry. Specific applications of ultrasonic welding to fabrication and encapsulation of transistors, transformer coils, bridgewire assemblies, electronic tubes, etc., are discussed.

The absence of electric current, thus eliminating arcing, sparking, and outgassing to contaminate surrounding areas; the low temperatures induced during welding; the fact that ultrasonic welds are solid-state bonds; the absence of intermetallics in the weld zone; and the elimination of complicated wet chemical prewelding operations, constitute advantages in processing and product quality that recommend consideration of this unique joining process for electronic components.

7.3. A Disquisition of the Innovations and Gadgetry Used in the Volume Production of a Super Power Electron Device

JAMES A. JOLLY, *Eitel-McCullough, Inc., San Carlos, Calif.*

The X626 is a super power klystron of gigantic size. It was specifically developed to produce over 80 kw of average power (1.25 mw peak power) at UAF frequencies for the Air Force Project BMEWS (Ballistic Missiles Early Warning System). Many papers have been written describing the complexity of producing microminiature electron devices. This paper is unique in that it describes the innovations and novel applications of production methods, procedures, techniques, and processes necessary to volume produce an electron device weighing more than 700 pounds and standing over 10 feet tall. A large number of detailed photographs are used to describe accurately the manufacturing operations.

7.4. Design and Manufacturing of a Simplified Grid Module

LEON JACOBSON, *General Electric Co., Syracuse, N. Y.*

This paper deals with a simplified method of assembling and connecting commercially available components in encapsulated modules.

Eyelets positioned on a perforated pallet are used to make the mechanical and electrical connection between the component leads and the interconnecting wires that have been inserted in these eyelets. These eyelets are dip-soldered while the assembly is still on the pallet.

The resulting web of components, wire, and eyelets is removed from the pallet and then folded or rolled, before encapsulating, to produce the completed module.

Having the layout and assembly in one plane simplifies assembly and also predetermines the position of the components.

7.5. Micromodule Components: A Review of the State of the Art

R. A. FELMLY, *RCA, Somerville, N. J.*

Component parts which perform the basic electronic-circuit functions have been developed for use with the micromodule system. Versatility of these parts has been demonstrated by a variety of modules designed for use in the types AN/PRC-36 Helmet Radio and the AN/TCC-26 Time Division Multiplex Equipment. This paper describes the mechanical characteristics and construction, electrical specifications, and performance of these various types of components.

Among the components now in microelement form are precision-film resistors, single and multilayer ceramic capacitors in both high-K and NPO bodies, tantalum electrolytic capacitors, germanium transistors, gold-bonded germanium and diffused silicon diodes, and microminiature toroidal coils for inductor and transformer applications. The latter components include IF, RF, and pulse types.

Components under current development include a trimmer capacitor, thermistors, RC filters and extended-range resistors, capacitors and inductors. All of these components are being designed to the micromodule form factor.

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* Sponsored by the Professional Group on Production Techniques. To be published in Part 6 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 8*

Mon. 2:30–5:00 P.M.

Coliseum
Morse Hall

ELECTRON DEVICES

Chairman: A. E. Anderson,
Western Electric Co.,
Allentown, Pa.

8.1. Rating Power Transistors for High Current Pulses

Peter Balthasar, *Bendix Aviation Corp., Long Branch, N. J.*

In most switching applications the maximum permissible collector junction temperature is the limiting factor. The junction temperature is a function of power, time, thermal resistances, and time constants. Therefore, the applied instantaneous power may exceed the rated dc power dissipation. In order to determine the equilibrium value of the peak junction temperature, theoretically derived equations are applied to the problem. Simplified approximations are made and compared to measurements. A procedure is outlined for determining by various design aids whether a transistor can be used for a certain pulse amplitude, pulse width, and pulse repetition rate combination.

8.2. An *N-P-N* Fusion Alloy Silicon Transistor for "Avalanche Mode" Operation

R. C. Wonson and W. A. McCarthy, *Raytheon Co., Newton, Mass.*

This paper describes an *n-p-n* silicon transistor operated in the "avalanche mode." Normally the transistor has a very low frequency limitation; it has switching times of approximately 2 μsec. When operated in the "avalanche mode," the transistor exhibits switching times of 2 mμsec or better.

Since the transistor is silicon, its high temperature performance has been examined in detail. Measurements techniques are described as well as inexpensive methods of determining performance.

Practical circuit applications are discussed with particular emphasis on a completely designed pulse generator.

8.3. Photoconductor Optical Encoders for In-Line Readout Devices

Carl Isborn, *Beckman/Berkeley Div., Richmond, Calif.*

This paper describes a method of using photoconductors to convert a four-line binary code into a seven-line code suitable for actuating a seven-segment visual display. The basic photoconductor amplifier is analyzed and performance data on typical mass-produced photoconductors are given. Photoconductor circuits that perform AND, OR, and NOT operations by converting electrical signals to optical signals and back to electrical signals are described. The logical equations defining the four-line to seven-line conversion are presented, and a conventional diode matrix for performing these logical operations is shown. An equivalent optical matrix is developed wherein light beams replace matrix diodes. The two conversion methods are compared with respect to performance, circuit complexity, and cost.

8.4. Advances in Screen Structure and Data Distribution for the ELF Display System

E. A. Sack, *Westinghouse Res. Labs., Pittsburgh, Pa.*

Microcircuit structures have been developed for the electro-luminescent-ferroelectric (ELF) display screen which achieve a display resolution of 256 elements per square inch. The switching matrix which distributes brightness information to the elements is an integral part of the screen. At present, multijunction silicon diode strips provide the switching function.

Model screens as large as eight inches wide by four inches high have been assembled. The highlight brightness of experimental models is on the order of 10 foot-lamberts with contrast ratios as high as 100/1. In one display system, information is distributed to the screen at a rate of 150 μsec per screen line with a frame-storage time of 5 seconds.

8.5. Shadow Grid VHF RF Tuner Tubes

F. R. Snyder and C. D. McCool, *General Electric Co., Owensboro, Ky.*

The addition of a grounded grid aligned with the screen grid, and placed between the control grid and screen grid, will reduce partition noise as a result of the increased plate current to screen current ratio. A plate to screen current ratio of 60/1 or more is obtainable with this construction, which is termed the shadow grid technique.

A shadow grid pentode VHF-RF tuner tube has been developed having a noise figure 1.5 db better than standard tetrode RF tuner tubes, and has 6 db more gain.

The shadow grid technique permits the plate voltage to be higher, equal to, or lower than the screen voltage. This circuit flexibility aids the equipment designer significantly in obtaining cost savings.

8.6. Focus-Reflex Modulation for Electron Guns

Kurt Schlesinger, *General Electric Co., Syracuse, N. Y.*

A new approach to high-efficiency guns for cathode-ray tubes has been developed. Emission from a large Pierce cathode is focused by deceleration, thus forming a small virtual cathode at the exit of a hyperbolic lens. Forward emission from this virtual cathode is controlled by an electron mirror before going through a spot-defining aperture. In operation, the mirror controls both the beam intensity and the focal length of the system. Ordinarily, both control functions are not coordinated.

In the present gun, focus modulation and intensity modulation are brought into coincidence by design. The resulting "focus-reflex" modulation features total cutoff and high control sensitivity (10 to 12 volts) as well as high beam current (1200 μa) and transconductance (G max = 300 μa/volt). Spot size is under control by an aperture.

The paper will describe the electron-optical design theory for focus-reflex modulation.

Photographs of finished FR gun assemblies and of their characteristics will be shown. Television applications will be mentioned as well as an adaptation of the new gun to radar service.

SESSION 9*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Starlight Roof

CONTROL APPLICATIONS

Chairman: Harold Chestnut,
General Electric Co.,
Schenectady, N. Y.

9.1. Decoupling Techniques in Multiloop Control Systems

Robert H. Loomis, *Westinghouse Electric Corp., Baltimore, Md.*

Decoupling is a design technique which permits the independent design of the several transfer functions in a multiloop control system.

It is described in this paper by illustrating its application to a particular system and describing the results attained.

The technique described has the following advantages:

1) The required "matching" takes place within the loop, so that the effect of any mismatch is attenuated by the open loop gain.
2) For the example used, the output angular rate accuracy becomes independent of aircraft motion.
3) Subject to the rather minor restriction implied by item 1, the two loops become independent as far as stability is concerned.

9.2. Optimum Compensation of a Position Servo with a Magnetic Clutch Actuator

R. J. Hruby, *Northrop Corp., Hawthorne, Calif.*

This paper presents a derivation of the two first-order time lags typical of magnetic clutches used for control actuators in missile servo applications and an exact analysis of two specific methods used for servo compensation of the magnetic clutch time lags. The two time lags arise from the inductive properties of the excitation coil and the clutch rotor induced eddy currents. The servo compensation for the excitation coil time lag consists of excitation current feedback to decrease the effective transfer function time constant. Basic servo stability is provided by a tachometer feedback branch. Optimized compensation for the first-order time lag arising from the induced rotor eddy currents is provided by a passive tachometer lead network.

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* Sponsored by the Professional Group on Electron Devices. To be published in Part 3 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Automatic Control. To be published in Part 4 of the 1960 IRE International Convention Record.

9.3. Synthesis of a Self-Adaptive Autopilot for a Large Elastic Booster

George W. Smith, *The Martin Co., Denver, Colo.*

The design of an autopilot system for a highly elastic booster requires taking into consideration a vehicle with a flexible structure having relatively low bending frequencies and very little structural damping. If any of the systems parameters deviate from the calculated nomial values, the system stability margins become dangerously low. This results in the conventional autopilot design being dependent on *a priori* knowledge of the exact structural parameters. To alleviate this situation, the design of a self-adaptive autopilot has been evolved, which will automatically adjust itself so as to maintain optimum performance in the face of changing structural parameters. Because the system involves rigid body modes, as well as elastic modes, the system in general has a characteristic equation of high order.

An autopilot system is described which makes provision for continuous interrogation of the system to determine its response. Criteria are developed for adjustment of internal gains and filter parameters so as to achieve optimum response. Mechanization of the autopilot as a sampled data control system is discussed.

9.4. Design of Optimum Beam Flexural Damping in a Missile by Application of Root-Locus Techniques

R. J. Hruby, *Northrop Corp., Hawthorne, Calif.*

The control of a missile in free-fall in the presence of external disturbances requires that the control system be stable when various body-bending modes are excited. The complexity of the control system depends upon the beam-flexural modal damping of the completed missile because all body-bending modes are excited by the rocket motor.

This paper explains how to use the subassemblies of a missile, such as the rocket motor or guidance package, to get a theoretical maximum increase in flexural damping by the proper design of the attaching fixtures of the subassemblies without weight or equipment complexity.

9.5. Flywheel Control of Space Vehicles

James E. Vaeth, *The Martin Co., Baltimore, Md.*

This paper will describe, and summarize the results of, an analytic study of inertia flywheels as employed for simultaneous three-axis attitude control of space vehicles.

The accomplished objectives of this study were to determine the requirements, capabilities, and limitations of flywheel autopilots as functions of desired accuracy and speed of response, disturbing moments, differential gravity restoring torques, component uncertainties, and vehicle initial attitude and attitude rate errors. The performance degradation (from the viewpoint of stability and accuracy) that results from *not* compensating for gyroscopic cross-coupling torques was determined by means of a three-axis analog computer study.

SESSION 10*

Tues. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Astor Gallery

DIRECT CONVERSION

Chairman: William A. Higinbotham, *Brookhaven Natl. Lab., Upton, N. Y.*

10.1. Thermoelectric Converters

Kurt Katz, *Westinghouse Electric Corp., Pittsburgh, Pa.*

Many advantages could be realized if it were possible to convert the heat energy produced, through fission, in a nuclear reactor directly to electrical energy. This paper will review the equations which define thermoelectric conversion efficiency, and the present status of materials for this application.

Several schemes for the conversion of fission-generated heat directly within the core zone will be described. The transfer of the fission-generated heat to an external thermoelectric converter unit will also be presented.

The advantages and disadvantages of each scheme will be described.

10.2. Thermionic Converters

Walter Grattidge, *General Electric Res. Lab., Schenectady, N. Y.*

A thermionic converter is a static high-temperature engine that converts heat to electricity. It is a vacuum or gas-filled device containing a hot cathode and a cold anode. Nuclear energy is an ideal heat source for a thermionic converter. The cathode and nuclear fuel element can be designed as an integral unit. The anode can be cooled by a conventional reactor coolant. Thus the converter can be an integral part of the fuel assembly. The anode temperature can be sufficiently high to permit the waste heat to be used in standard steam turbines. Thus the converter becomes a "topper" to the steam turbine and augments its performance.

10.3. Noble-Gas Plasma-Diode Thermionic Converter

F. E. Jamerson, *General Motors Res. Labs., Warren, Mich.*

The direct conversion of nuclear heat to electricity is being investigated in a plasma diode that utilizes fission fragments from a uranium-bearing cathode to produce a plasma in a noble gas. The fractional ionization is relatively low, but the electron mobility in a noble gas is relatively high so that a reasonable diode impedance might be attained. The advantage of such a diode converter is that it eliminates the use of an alkali metal as used in other plasma diodes. The results of an experiment with a noble-gas plasma diode operated in the University of Michigan reactor will be discussed. In this experiment a uranium carbide cathode was operated up to a temperature of 2000°K. Some results of an initial theoretical analysis of the noble-gas plasma diode will be given.

10.4. Magnetohydrodynamic Approaches

Richard J. Rosa, *Avco-Everett Res. Lab., Everett, Mass.*

This paper starts with a brief review of the basic theory of magnetohydrodynamic (MHD) power generators and describes an experimental MHD generator which has been built at the Avco-Everett Research Laboratory.

MHD power plant cycles are discussed. A cycle designed for use with a nuclear reactor is described. The reactor in this case would need the same temperature capability as those now being developed for nuclear rocket propulsion although it might not, depending upon the application, require such a high specific power output.

The basic electrical properties of gases are reviewed briefly, and their dependence upon temperature, pressure, and composition is discussed. Over-all performance characteristics of MHD generators are presented as a function of these gas properties. This gives an indication of the future potential of MHD as a conversion technique.

Some of the possibilities for the future are discussed in which more exotic forms of high-temperature reactor combined with an MHD generator may make possible systems having, by present standards, very high efficiency, low cost, and/or light weight.

10.5. Direct Conversion—Where Do We Stand?

Robert J. Pidd, *General Dynamics Corp., San Diego, Calif.*

Several schemes have been advanced for the direct conversion of heat into electricity. These schemes will be reviewed and compared with respect to such technical parameters as efficiency and output and such programmatic factors as the state of the art and development required.

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* Sponsored by the Professional Group on Nuclear Science. To be published in Part 9 of the 1960 IRE International Convention Record.

SESSION 11*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

BROADCASTING—I

Chairman: RAYMOND ROGERS, *Westinghouse Broadcasting Co., Inc., KDKA, Pittsburgh, Pa.*

11.1. Report on Geneva Radio Conference

W. H. WATKINS, *FCC, Washington, D. C.*

The Administrative Radio Conference of the International Telecommunication Union was held in Geneva, Switzerland, starting on August 17, 1959, for the purpose of revision of the Radio Regulations which were formulated at Atlantic City in 1947 and subsequently were annexed without change to the Buenos Aires Convention of 1952. An explanation of the organization of the conference will be given from both a national and an international point of view. The accomplishments of the conference will be discussed along with comments on how the new radio regulations will affect users of the radio spectrum in this country.

11.2. Future Possibilities for Film Room Mechanization

JAMES H. GREENWOOD, *WCAE-AM/FM and WTAE-TV, Pittsburgh, Pa.*

Complete mechanization of the film and slide operations in a television station is somewhat restricted by the characteristics of presently available equipment. This paper describes equipment which could be produced today, which would reduce the projectionist's work load and at the same time result in smoother programming as well as reduced chances for errors. The equipment components are equally suited to manual or machine switching.

On existing slide projectors, slides are shown alternately from two drums or disks, making it difficult to reuse a slide in a series or to add or delete slides. This paper discusses various methods of improved usage by the use of storage tube techniques. It also discusses methods and techniques for improved film projection operations and methods by which they might be accomplished.

11.3. Directional Antennas for Television Broadcasting

GEORGE H. BROWN, *RCA, Princeton, N. J.*

Desirable operating characteristics and other requirements of directional transmitting antennas, suitable for television broadcasting, are considered. Basic limitations on directivity are imposed by long-distance propagation phenomena. Previous experience with directional antennas used for television broadcasting is reviewed. A number of appropriate antenna types are suggested.

11.4. Service Area of an Airborne Television Network

MARTIN T. DECKER, *Natl. Bureau of Standards, Boulder, Colo.*

An educational television network using UHF transmissions from aircraft has been suggested as a means to provide improved classroom instruction to schools throughout the country. Initial airborne tests will begin in 1960. As a step in the evaluation of such a network, calculations have been made which describe the coverage from an airborne station in the presence of interference from other stations. The results should be useful in determining the equipment and channel requirements of a nation-wide network. These requirements will be compared with those necessary to provide equivalent coverage from ground-based UHF stations.

SESSION 12*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Sert Room

AUDIO

Chairman: HARRY A. PEARSON, *Sonotone Corp., Elmsford, N. Y.*

12.1. A Plotter of Intermodulation Distortion

EDWARD F. FELDMAN, *Panoramic Radio Products, Inc., Mount Vernon, N. Y.*

For use mainly in audio systems, the instrument plots, on a CRT screen or chart recorder, the amplitude of the first-order difference frequency tone vs the lower excitation frequency in CCIF intermodulation distortion measurements. The unit furnishes two swept, equal-amplitude tones with a selected audio difference frequency to excite the tested system. Readout is on a modified audio frequency spectrum analyzer which remains tuned to the difference frequency. The automatic excursion provides considerable test time economy in evaluation of such devices as loudspeakers which exhibit wide variation in intermodulation with excitation frequency. Conventional point-by-point techniques run the risk of missing critical conditions.

The test set is also capable of tracking third-order distortion, $(2f_1 - f_2)$. Residual IM distortion is more than 80 db below the level of a single tone. A conventional swept spectrum analyzer and slave frequency response curve tracer are included in the complete system. Switching functions permit alternate displays on successive scans of any two of the modes of operation. For example, acoustic output and IM distortion vs frequency of loudspeakers may be plotted alternately for rapid evaluation.

12.2. Listener Ratings of Stereophonic Systems

HARWOOD B. MOORE, *General Electric Co., Utica, N. Y.*

Assorted stereophonic phonograph systems for the home were listened to under controlled conditions by numerous observers. The observers were given complete freedom to select alternately between system A and system B and asked to indicate a preference.

Each system was given the benefit of doubt by employing high quality amplifiers and speakers and each system was adjusted according to its theoretical description but with equivalent listening response characteristics.

This report describes the test conditions, test equipment, and test data obtained from the observers. Simple statistical logic has been applied to the data to present a phonograph system rating guide.

12.3. Calculation of the Gain-Frequency Characteristic of a Multimesh Transistor Amplifier Stage Using a Programmed Computer

D. E. BRINKERHOFF, *General Motors Corp., Kokomo, Ind.*

Electronic circuit designs are most commonly made by "analog" (or "breadboard") methods. This is particularly true in arriving at the desired gain and frequency response characteristics. An electronic circuit is essentially an analog computer and many parameters can be evaluated and quickly optimized by the "decade box method." On the other hand, a mathematical treatment of the equivalent multiple mesh circuits produces multiple simultaneous equations with multiple complex, frequency dependent coefficients which often require days instead of minutes to solve by hand calculation.

The introduction of the high-speed digital computer has made the mathematical approach not only feasible but in many cases faster than the breadboard method.

This paper will discuss the calculation of gain vs frequency of a transistor audio amplifier used in the output stage of an auto receiver. It will also investigate the effect of varying some of the parameters on the over-all gain and response of the stage.

12.4. Automatic Compensation of an Audio System Spectrum Operating with a Random Noise Input

CHARLES E. MAKI, *MB Electronics, New Haven, Conn.*

A set of 80 filters is used to divide a random noise input spectrum of an audio system into 25-cps increments. An identical set operating as a spectrum analyzer provides a similar function on the system output. By means of an automatic regulating system using solid-state electronics, each of the 80 loops is closed independently, thus providing a unique control system compensating the audio system spectrum and equalizing disturbing resonance phenomena. This method has been successfully applied to the control of a vibration system spectrum where mechanical resonances at the exciter table produce high Q peaks and notches. The degree of spectral flatness reveals that adequate compensation is possible for typical resonance phenomena occurring in the frequency range above 500 cps. Expected improvement using narrower band-pass filter characteristics is presented.

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* Sponsored by the Professional Group on Broadcasting. To be published in Part 7 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Audio. To be published in Part 7 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

12.5. An Analysis of Factors Affecting Recording Reliability and Digital Tape Recorders

KEN TAYLOR, *Ampex Corp., Redwood City, Calif.*

This paper develops the factors affecting recording reliability of digital magnetic tape equipment—primarily tape dropouts and dropout detection systems. The factors causing dropouts and the effects of dropouts are analyzed and classified. The relationship between packing density and recording reliability is presented, and methods are presented to determine maximum system reliability. The problems of head-to-tape contact are analyzed and means are presented to yield optimum head-to-tape contact in terms of reliability. The factor of maximum pulse resolution is also described, in terms of reliability. The conclusions drawn are that by sacrificing resolution for insensitivity of head-to-tape separation, the result should be a digital recording system which is operating at near optimum reliability for its specific packing density.

SESSION 13*

Tues. 10:00 A.M.–12:00 NOON

Waldorf-Astoria
Grand Ballroom

ENGINEERING MANAGEMENT—II

Chairman: JOHN R. RAGAZZINI, *College of Engrg., New York University, New York, N. Y.*

13.1. More Effective Engineering Proposals, One Key to Success

FRANK W. EVANS, JR., *Dept. of the Navy, Washington, D. C.*

Successful engineering proposals assure new contracts; new contracts sustain a healthy business; a healthy business generates profits with which to create new capacity and capability.

The mission of an engineering proposal is to convince the prospective customer that your company's solution to his engineering problem is best, that your personnel and facilities are eminently qualified to accomplish his technical and production objectives.

The ABC's of successful proposals are Accuracy, Brevity, and Clarity which must be supported by technical honesty and design simplicity.

Engineering proposals must particularly demonstrate a high standard of technical excellence and accomplishment plus management interest in and support of the over-all program.

13.2. The Application of Closed Loop Control Techniques to Engineering Project Planning and Control

R. W. HAINE AND W. LOB, *Bendix Aviation Corp., Teterboro, N. J.*

In order to complete an engineering project within specification, allotted funds, and scheduled length of time, it is necessary to program the various phases of the project in great detail. Furthermore, a system for feeding back information for corrective action during the operation of the project is required to eliminate and avoid major departures from specifications, expenditures, and schedules.

This paper describes a system for planning engineering projects and controlling them by means of feeding back information on their progress periodically. The paper also shows the corrective measures used when deviations to the initial plans become apparent.

13.3. The Professional Register—A Program for Improving Engineering Management Visibility of Technical Capabilities

N. A. BEGOVICH, *Hughes Aircraft Co., Fullerton, Calif.*

The Professional Register recently installed in the Ground Systems Group of the Hughes Aircraft Company, Fullerton, Calif., is designed to serve three purposes:

1) To provide technical personnel with an opportunity to record significant aspects concerning their background and career progress.
2) To provide a mechanism for locating internal candidates for reassignment purposes.
3) To provide information concerning the capabilities of engineering and scientific staff members for contract proposal and bidding purposes.

The program is implemented as follows. Each scientist and engineer will be provided an opportunity to specifically record background information, such as engineering specialty fields, education, and professional accomplishments. This information will be submitted on especially designed individual portfolios. Data are then translated via automatic data processing equipment and are made available for review on direct reading machine reports. As the need arises for personnel reassignment purposes or proposal capabilities, the master inventory is searched or summarized to provide the required information.

13.4. Management Control of Engineering Effort Through Graphic Methods

B. P. GOLLOMP, *Bendix Aviation Corp., Teterboro, N. J.*

This paper describes a graphic method for the preparation of engineering forecasts and budgets. Curves are employed to depict a project plan and its status. Other curves indicate the necessary planning corrections required as a project progresses. A third group of curves is used to indicate group or department status. Project and department budgets can be prepared from the aforementioned curves. The major advantages of the system are 1) individual and group professional abilities and talents, project complexity, and a variety of subjective factors are considered in the system, and 2) plans and status can be displayed and analyzed with a minimum of difficulty and training.

SESSION 14*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum
Faraday Hall

VARIED VIEWS OF MEDICAL ELECTRONICS

Chairman: H. H. ZINSSER, M.D. *New York, N. Y.*

14.1. Introductory Remarks—Training of Medical Engineers

H. H. ZINSSER, M.D., *New York, N. Y.*

The structure of medical engineering can be thought of as bridging links across multiple disciplines. Unlike biophysics, which depends primarily on mathematical or physical analytic techniques, medical engineering has its primary emphasis on synthesis, drawing on second-order derivations from at least two already derived disciplines, themselves one step removed from the basic sciences. As such a secondary derived area of learning and endeavor, it necessitates a wide range of basic knowledge and an open inquiry into techniques not as yet applied or in some cases even derived.

The essence is the applied synthetic art. As medicine and medical research become increasingly attractive as alternatives to purely analytical or destructive disciplines, it can be hoped that the synthesis of the practical and human oriented points of view that both professions share alike can merge mankind as painlessly and profitably as possible.

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* Sponsored by the Professional Group on Engineering Management. To be published in Part 10 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Medical Electronics. To be published in Part 9 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

14.2. Automatic Measurement of Enzyme Activity

Daniel I. Weinberg, *Astra, Inc., Raleigh, N. C.*

Many enzymes can be assayed by measuring the rate of change of optical density of a component of the reaction mixture. The component may be the enzyme, its substrate, or a compound which interacts with the reaction products.

The device described in this paper was originally designed to assay adenosine triphosphatase in fluids. This enzyme splits its substrate, adenosine triphosphatase, releasing an acid which changes the optical density of phenol red, a pH indicator.

The device will store one hundred samples, add reagent to, and measure the rate of change of optical density of each, record this measurement and the sample number on a paper tape, and, when finished, turn itself off.

14.3. Biological Microwave Hazards

Victor T. Tomberg, *Biophysical Res. Lab., Elmhurst, N. Y.*

The increase in microwave power for radars and industrial applications makes it necessary to revise former standpoints taken in physicotherapeutical applications of short waves and microwaves.

It is known that there are three classes of microwave field actions which have biological significance: 1) ordinary thermal effects, 2) specific thermal effects, and 3) electric effects. At low doses those actions are stimulative and beneficial, but at higher doses are harmful and destructive. Most of the hazards are produced by the specific thermal actions, even at low field intensities, of 1 watt per square cm and less. Specific thermal effects are often mistaken for electric effects, particularly in nonhomogeneous bodies or suspensions where parts or particles have a different dielectric behavior compared with the surrounding medium. Boundaries and interfacial layers act on the high-frequency field distribution, change the absorption pattern of the microwave field, and exert a focusing action which makes the value of the average field intensity meaningless so far as it concerns the safety requirements in some cases. Eyes and testicles are often vulnerable parts of the body. At low intensity fields we have to consider the voltage gradient and resonant phenomena more than the average field intensity.

Pearl chain effects are electrical effects mostly independent of the frequency. Because they only prevail when there is no significant thermal action, they do not constitute a biological hazard.

14.4. An Automatic Physiological Telemetry and Analog-to-Digital Conversion System

W. E. Sullivan and C. A. Steinberg, *Airborne Instruments Lab., Deer Park, N. Y.*; J. T. Farrar, M.D., *Veterans Administration Hospital, New York, N. Y.*

Intraluminal pressure recordings provide valuable information concerning the motility within the gastrointestinal tract. Conventional methods for recording of pressure changes within gastrointestinal tract require the passage of tubes through the mouth, nose, anus, or through an artificial opening. An instrument has been designed to record the gastrointestinal motility with a minimum discomfort to the patient. This instrument consists of an ingestible pressure-sensitive telemetry capsule (pressure transensor) and an associated monitoring receiver.

The resulting recordings of gastrointestinal pressure are very complex and difficult to categorize. It was felt a general-purpose digital computer would greatly aid in the characterization of these complex waveforms. Thus, a system has been designed to take these gastrointestinal waveforms along with other physiological measurements, digitize this analog data, and record the analog data on magnetic tape in a format compatible with an IBM 704 computer.

14.5. Panel: Significant Variables in Biophysical Evaluation of the Human Under Stress

Chairman: C. D. Ray, *University of Tennessee, Division of Surgery, Memphis, Tenn.*

Panel Members: L. Clark, *Medical College of Alabama, Birmingham, Ala.*; Members of the Staff of Col. J. P. Stapp, *Aero Medical Div., WPAFB, Ohio*; O. H. Schmitt, *University of Minnesota, Minneapolis, Minn.*

The panel will discuss the general physiological pattern to be followed in measuring the significant variables of the human under stress; the use of internal electrodes for tissue sampling; currently practical methods of gathering physiological data and what variables prove most fruitful under acute stress; and what physiological variables should be measured, including direct and integrated physiological functions.

SESSION 15*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum
Marconi Hall

MODERN APPROACHES FOR IMPROVED AIR TRAFFIC MANAGEMENT

Chairman: Alden C. Packard, *FAA, Washington, D. C.*

15.1. An Air Height Surveillance Radar (AHSR-1)

Thompson J. Simpson, *FAA, Washington, D. C.*

The Air Height Surveillance Radar (3-D) currently under development by the Federal Aviation Agency is a passive S-band receiving system which is used in conjunction with an airport surveillance radar as a source of target illumination. The system is capable of resolving two aircraft located fifty nautical miles distant from the antenna at the same azimuth and separated in elevation by 1000 feet. With a vertical aperture of 150 feet, the antenna produces about 115 separate receiving beams, the lower group having a beamwidth of about 0.19°. The output of each beam is fed to an individual receiver/beam-selector/height-computer channel. A beam-selector matrix determines in which beam the target is located and with the aid of a computer determines the actual height of the target. The various height outputs then are used for special 3-D displays in addition to providing for three-dimensional automatic target tracking within the Data Processing Central System.

15.2. Automatic Ground-Air-Ground Communications for Control of Air Traffic

Wayman R. Deal, *FAA, Washington, D. C.*

Voice radio channels forming the vital links for the control of civil and military air traffic are becoming seriously congested. Studies have shown that by 1970 air traffic control communications will quadruple the 1958 volume. Automation through the use of a data link offers a practical means to relieve congestion and provide growth potential to keep pace with the rapid acceleration in communication requirements.

The Federal Aviation Agency has developed the Automatic Ground-Air-Ground Communications System (AGACS) as an initial step in mechanizing routine communications. This experimental equipment is currently under evaluation at the National Aviation Facilities Experimental Center. The paper briefly describes the system and presents the results of the evaluation program to date.

15.3. Technical Research for Future Aviation Facilities

N. Braverman, W. W. Felton, S. Justman, R. E. Kester, Maj. L. J. Schaub, USAF, and A. Wetter, *FAA, c/o NAFEC, Atlantic City, N. J.*

This paper covers the role of technological research in the development of aviation facilities which can keep pace with the increasing number and expanding requirements of the users of the airspace. The methods for selecting new techniques for investigation are examined. The need for carrying on technological system synthesis simultaneously with the technical studies is explained. A discussion is included regarding the relationship of technical system synthesis to the study of the technical factors which are common to form a system of facilities. Reported are the objectives and progress to date of several research efforts which have been started within the Bureau of Research and Development of the FAA.

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* Sponsored by the Professional Group on Aeronautical and Navigational Electronics. To be published in Part 8 of the 1960 IRE International Convention Record.

15.4. A Mathematical Analysis of the Performance of the ATC Radar Beacon System

A. Ashley and F. H. Battle, Jr., *Airborne Instruments Lab., Mineola, N. Y.*

A mathematical model representing the Air Traffic Control Radar Beacon System operation in the current New York environment has been developed to evaluate the effects of 1) changes in system parameters, and 2) incorporation of various combinations of system improvements. The combined effect of all stations on the reply rates from individual aircraft in the area is calculated, as well as the total reply information available for display and utilization at the Idlewild en route beacon station. To indicate the optimum future configurations, the computations are performed for combinations of 1) the basic system and three different sidelobe suppression techniques, 2) receiver subtraction, 3) single and double defruiting, and 4) several decoder settings. Various settings of dead-time, suppress-time, and reply-limit are imposed on each of the combined systems. Conclusions and recommendations are presented.

SESSION 16*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

BROADENING DEVICE HORIZONS

Chairman: M. E. Hines, *Bell Telephone Labs., Murray Hill, N. J.*

16.1. Masers

J. W. Meyer, *M.I.T. Lincoln Lab., Lexington, Mass.*

16.2. Variable Reactance Devices

B. Salzberg, *Airborne Instruments Lab., Mineola, N. Y.*

16.3. Tunnel Diodes

H. S. Sommers, Jr., *RCA Res. Lab., Princeton, N. J.*

16.4. Functional Devices

W. A. Adcock, *Texas Instruments Inc., Dallas, Tex.*

The advent of new active elements on the device horizon and the combination of several elements in more complex functional devices promise to broaden the vista of the electronics industry. The panel of speakers will present coordinated talks aimed at a broad coverage of these new devices. This will include a description of the fundamental aspects of the devices, a summary of the present state of development and an indication of some of the device development and application possibilities of the future. The chairman will present a brief summary and the final part of the meeting will consist of a panel discussion and questions from the floor.

SESSION 17*

Tues. 2:30–5:00 P.M.

Waldorf-Astoria
Starlight Roof

RADAR AND CODING THEORY

Chairman: George L. Turin, *Hughes Aircraft Co., Culver City, Calif.*

17.1. Sequential Procedures in Radar Pretracking

Mischa Schwartz, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

Two schemes for the preliminary tracking of a target in a combined and automatic detection-tracking radar are discussed and analyzed.

These serve as detection verification procedures, decreasing the number of times noise is erroneously tracked as a true target. They are sequential procedures in which a definite decision to track a target is withheld until the signal measured exceeds the upper of two threshold levels.

The average number of radar scans beyond the detection scan is found to be between one and two, for a given high probability of discarding noise and correctly tracking a signal.

17.2. Detection Range Predicting for Pulse Doppler Radar

S. A. Meltzer and S. Thaler, *Hughes Aircraft Co., Culver City, Calif.*

A mathematical model of sufficient flexibility to describe most pulse Doppler radar search systems is constructed and used to predict detection ranges. It is applicable to situations where thermal noise or sidelobe clutter limits detection range. The sidelobe clutter is assumed to be statistically similar to thermal noise. The model allows the variation of most of the important radar parameters. The receiver is assumed to have a number of rectangular, nonoverlapping range gates followed by narrowband, Gaussian-shaped Doppler filters and then a square law envelope detector followed by a post-detection filter consisting of one or two stages having exponential weighting functions. Single scan and cumulative probabilities of detection are calculated for both steady and scintillating targets.

17.3. The Search Efficiency of the Sequential Probability Ratio Search Radar

Glenn W. Preston, *General Atronics Corp., Bala-Cynwyd, Pa.*

This report describes a method of radar signal detection and search in which signal detection is accomplished by a sequential probability ratio detector and the beam scanning is controlled by the detector. A theoretical improvement typically of 5 to 8 db is gained over nonsequential search radars which are otherwise identical.

17.4. Group Codes for Correcting Prescribed Error Patterns

Robert T. Chien, *IBM Res. Center, Yorktown Heights, N. Y.*

This paper studies the problem of constructing group codes for correcting error patterns. An equivalence relation is defined and error patterns are divided into equivalence classes. If a group code can be constructed for any pattern, a transformation technique will give group codes for all error patterns in the same class. For any error pattern, a necessary and sufficient condition for the existence of a correcting group code is given. Procedures for constructing group codes are illustrated for patterns which fulfill the condition. In the case $r=3$, out of more than 10^7 matrices, only 20 equivalence classes were found.

17.5. Some Results on Best Recurrent-Type Binary Error-Correcting Codes

William L. Kilmer, *Montana State College, Bozeman, Mont.*

This paper treats error-correcting codes consisting of binary message sequences augmented by periodic insertions of parity check digits. The codes are studied in terms of a parity check matrix, M, an error pattern vector, and a parity check sequence vector. Problems concerning the codes can be reduced to questions about the columnar sum properties of M. Answers are given to many important questions regarding the burst-correcting properties of the codes. These answers are based on the specification of a mathematical group of binary sequence patterns. The codes can be designed to have easily instrumentable and highly efficient error-correcting properties.

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* Sponsored by the Professional Group on Electron Devices. To be published in Part 3 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Information Theory. To be published in Part 4 of the 1960 IRE International Convention Record.

SESSION 18*

Tues. **2:30–5:00 P.M.**

Waldorf-Astoria
Astor Gallery

INDUSTRIAL ELECTRONIC INSTRUMENTATION

Chairman: JOHN J. GRAHAM, *RCA, Camden, N. J.*

18.1. An Inquiry into the Computer Automation of Supermarkets

RONALD R. SEGEL, *Thompson-Ramo-Wooldridge, Inc., Los Angeles, Calif.*

This is the age of automation. There is one facet of this that touches each one of us and that is the automation of supermarkets. Anyone who has stood for a long time at a checkstand waiting to be checked out will attest to the need. This paper has to do with machine recognition of the price of a supermarket item or of a code number upon the merchandise. The machine will take the place of the person who now operates the cash register and in addition will aid in inventory control. This paper covers the technical and philosophical aspects of an automated system. It points out several proposals that have been tried and some that are new.

18.2. Automatic Testing and Calibration of Central Air Data Computer

H. LANGENTHAL, *Bendix Aviation Corp., Teterboro, N. J.*

An automatic test set for the production testing and calibration of Central Air Data Computer System is described. A punched tape programming device is used to select the inputs, which consists of an electrical signal equivalent to an angular position of an autosyn to a resolution of 0.1°. A second punched tape programming device is used to select and channel on a parallel entry printer a maximum of 10 switch closures, 10 preselected capacitor values, 30 potentiometers, 20 autosyns, and 2 digitizers. The recorded information is displayed on a preprinted data sheet showing upper and lower tolerances. Calibration time will be cut approximately in half.

18.3. Electronics in Agriculture

F. C. JACOB, *University of California, Davis, Calif.*

Factors are outlined which favor and oppose the use of electronics in agriculture. Agriculture is compared with other industry regarding the need for automation. Current applications of electronics directly to agriculture are reviewed. Comments are made on experimental work now in progress on electronic equipment for agriculture and also on instrumentation necessary for progress in agricultural research but not necessarily leading to direct application. Finally, speculations on possible applications are offered.

18.4. The Shawmeter—An Electronic Two-Color Pyrometer

VINCENT G. SHAW, *Shaw Instrument Corp., Latrobe, Pa.*

This paper briefly discusses the advantages of two-color pyrometry over some better known temperature measuring devices. The electronic aspects of the instrument are covered in considerable detail. Potential sources of trouble in an instrument of this type and how they have been avoided are discussed. A few typical applications involving the Pyrometer in some industrial automation problems are reviewed.

The author attempts to show how the correct combination of electronic and physical principles can result in a device which is ideally suited for the ever-growing trend towards industrial automation.

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* Sponsored by the Professional Group on Industrial Electronics. To be published in Part 6 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 19*

Tues. **2:30–5:00 P.M.**

Waldorf-Astoria
Jade Room

BROADCASTING—II

Chairman: WILLIAM HUGHES, *Iowa State College, Ames, Iowa.*

19.1. Some Engineering Aspects of Video Tape Recording Production

EDWARD E. BENHAM, *KTTV, Inc., Hollywood, Calif.*

Hollywood is the focal point of film and live TV productions. It should become a major video tape production area. There is much activity along these lines, and this paper will describe some of these activities and the major role that engineers will play.

The approach of VTR productions should be patterned neither for live television or film, but rather somewhere between the two. In general, video tape recording productions can be divided into four sections: preproduction planning, production, postproduction editing, and laboratory work. In each, careful engineering planning can save time, facilities, and money.

The use of VTR as an economical production tool in transferring to film for release has increased the over-all usage of video tape, but requires that the end medium of release must be considered in the original productions.

The laboratory portion of the production is where the prints are made, rerecording either for video tape recording or film transfers, and final quality improvements are worked into the final release.

Many engineering details of the various steps will be described and the necessity of careful consideration of the total problem at the outset of any production will be discussed.

19.2. A Modern TV Transmitter Plant Input System

JOSEPH L. STERN, *CBS-TV, New York, N. Y.*

As the final link in the television transmission system the transmitter plant has an extremely high responsibility. To meet this responsibility it must have an input system that can act as a nerve center and be capable of simple signal processing, continuous monitoring, automatic alarm signaling, and instant emergency action. As part of a program of plant updating and quality improvement, a completely new and simple transmitter plant input system has been designed. The key features of the system are:

1) "Human engineered" controls,
2) Remote controlled emergency by-pass circuits,
3) Simplified jack-fields,
4) Push button audio and video monitoring,
5) Automatic homing for normal monitor circuits.

System design, circuit and operating details are described.

19.3. A Special Effects Amplifier for Noncomposite or Composite Monochrome or Color TV Signals

RALPH C. KENNEDY, *NBC, New York, N. Y.*

A switching circuit has been designed to produce a doublet impulse transition of 0.05 μsec. The problem of clamping a color signal during the burst interval by means of crystal diodes is discussed and a solution presented. Nonlinear amplification of the switching data prior to regenerative clipping has been found to permit dependable switching with much smaller brightness changes.

19.4. Remote Control of TV Microwave Equipment

JOHN B. BULLOCK, *RCA, Camden, N. J.*

Recent actions by the FCC have made it possible for privately owned and operated microwave links to be constructed by television stations. The need for remote control of the systems has brought about the development of some novel techniques for input switching, system reversal, and the transmission of control information. Hardware designed for these functions will be described.

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* Sponsored by the Professional Group on Broadcasting. To be published in Part 7 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 20*

Tues. **2:30–5:00 P.M.**

Waldorf-Astoria
Sert Room

AUDIO AND BROADCAST AND TELEVISION RECEIVERS

Chairman: Daniel W. Martin,
The Baldwin Piano Co.,
Cincinnati, Ohio.

20.1. The Present Status of Stereo Broadcasting

C. G. Lloyd, *General Electric Co., Auburn, N. Y.*

20.2. Receiver Design Considerations for Stereophonic FM Multiplex Broadcasting

C. G. Eilers, *Zenith Radio Corp., Chicago, Ill.*

Circuits within the receiver are analyzed relative to stereophonic crosstalk. Various circuit approaches for demodulating the subcarrier are discussed and compared on the basis of complexity, stability, and performance. Effects of multipath and ignition pulse interference on stereophonic receiver performance are described.

20.3. The Percival Stereophonic System

W. S. Percival, *Res. Labs., Electric & Musical Industries, Ltd., Hayes, Middlesex, England.*

The purpose of the system is to provide a stereophonic signal for radio transmission within a bandwidth only slightly greater than that required for ordinary monophonic transmission. The left and right microphone signals are combined to form a single AF signal which is available for ordinary monophonic reception. They are also processed in such a way as to emphasize the beginnings of sounds and then utilized to form a signal, with a bandwidth of 100 cps carrying the directional information only. This directional signal is caused to modulate a subcarrier at a power level much lower than that of the AF signal. In the receiver the AF signal and the directional signal are applied to a Hall multiplier unit giving the required left-loudspeaker signal as one output and the right-loudspeaker signal as the other.

20.4. A Continuously Variable Wireless Remote Control for Stereophonic Phonographs

A. A. Goldberg and A. Kaiser, *CBS Labs., Stamford, Conn.*

This describes an ultrasonic remote control for a stereophonic phonograph that provides continuous control of volume and stereophonic balance as well as record reject. The design incorporates techniques for immunizing the system against spurious signals.

Control of the separate functions is accomplished by transmitting and receiving one of three CW ultrasonic signals. Noise immunization is inherent in the logical circuitry that precludes operation if more than one frequency is received.

The transmitter consists of a transistor generator and a ceramic transducer. The receiver employs a similar transducer and a broadbanded 3-stage amplifier-limiter driving frequency selective circuits to trigger one of 3 thyratrons. Two of the thyratrons form part of a bridge to control the rotation of dc motors coupled to the volume and balance potentiometers. The third thyratron controls the record reject solenoid.

20.5. Automatic Stereophonic Phaser

B. B. Bauer, A. A. Goldberg, and G. Pollack, *CBS Labs., Stamford, Conn.*

With the advent of sterophonic records and broadcasting, there is a need for a device that can sense the phasing of the Left and Right signals and automatically make corrections if necessary.

The CBS Laboratories' Automatic Stereo Phaser bridges the Left and Right program lines, linearly amplifies each signal and then converts them to $L+R$ and $L-R$ signals by means of a transformer matrix. The $L+R$ and $L-R$ signals are separately rectified and the resulting dc is applied to a mechanical flip-flop. Correct phasing results in a greater $L+R$ signal as compared to the $L-R$ signal. If the reverse appears, the program lines are automatically rephased.

SESSION 21*

Tues. **2:30–5:00 P.M.**

Coliseum
Faraday Hall

THE HUMAN AS ORIGINATOR OF SIGNALS AND SCHEMES

Chairman: H. H. Zinsser, M.D.,
New York, N. Y.

21.1. Implantable Cardiac Pacemakers

Wilson Greatbatch, *Electronics Consultant, Clarence, N. Y.*

The state of the art of transistor electronics is approaching the point where serious consideration can be given to implanting electronic devices in the human body for periods of unattended service of up to five years. The cardiac pacemaker represents an ideal application for this class of equipment. This paper will discuss the requirements of such a pacemaker. A sample unit will be demonstrated that has actually been implanted in an experimental animal and has been in successful operation for over three months.

21.2. Detection and Analysis of High-Frequency Signals from Muscular Tissues with Ultra-Low-Noise Amplifiers

W. K. Volkers, M.D., *Millivac Instruments Div., Cohu Electronics, Schenectady, N. Y.,* and W. Candib, M.D., *St. Claire Hospital, Schenectady, N. Y.*

The recent perfection of low-noise amplifiers, such as the Hushed Transistor Amplifier, makes it possible to investigate exceptionally weak electromagnetic signals which are generated by the human body. Before such low-noise amplifiers were developed, the only effective means of suppressing amplifier noise was a rather drastic reduction of bandwidth, and investigations quite naturally confined themselves mostly to the low-frequency region (cardiographs and encephalographs). Now available, greatly improved, wide-band low-noise amplifiers enable us to study low-level signals generated by the body, over much wider frequency ranges than before. For instance, the deltoid muscle (in the shoulder), or the gastrocnemius muscle (calf muscle of the leg) generate sharply spiked signal waves when contracted; these waves contain frequency components up to well over 10 kc.

The paper describes the test equipment which combines a Hushed Transistor Amplifier with a new, especially developed, narrow IF band heterodyne postamplifier which is used to scan the frequency spectrum of muscle voltages. Typical spectra for various muscles are discussed, also pathological deviations in muscular structure (such as scleroderma, or thickening, scleroedema, or retention of water in tissue, and ischemic conditions, or diminished blood supply). These abnormalities influence the frequency spectrum of the muscle. Therefore, the low-level, high-frequency measurements of muscle voltages described in this paper promise to become an important tool for diagnosis of muscular diseases in the future.

21.3. The Stereo-Dynamic Aspects of Fetal Auscultation and Its Application to Medical Diagnosis

L. E. Garner, Jr., *Silver Spring, Md.,* and F. D. Napolitani, M.D., *Mount Vernon, N. Y.*

This paper reveals the use of mono- and diphonic transducer pickups to the uterus and its contents. It also reveals the effects of picking up sonic depth sounds in the body, similar to work done on reflection of pathological bone. The attempt is indicated for development of a clinical tough inexpensive method of predicting fetal and maternal mortality, so that necessary steps may be taken to reduce this danger. Recourse is made to the use of small-size permanent-type magnetic speakers with the paper cone attached to a solenoid coil, floating in the narrow air gap of a permanent magnet. A 45-ohm best impedance match was used, and the interpretation of sounds from an artificial chamber were measured, as were actual clinical experiments conducted in a large city hospital, cases then undergoing Caesarian section, verifying the suspicions pointed to by the electronic transducer. Medical possibilities are indicated, and the future use of such an instrument, now being questioned as Laennec with his first ear-scope, may well reach the stage of the common stethoscope.

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* Sponsored by the Professional Groups on Audio and Broadcast and Television Receivers. To be published in Part 7 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Medical Electronics. To be published in Part 9 of the 1960 IRE International Convention Record.

21.4. Use of a High Sensitivity Capacitance Pickup in Heart Sound Research

D. Groom, M.D. and Y. T. Sihvonen, *Medical College of South Carolina, Charleston, S. C.*

The authors have been impressed with a need for electronic techniques capable of detecting and recording heart murmurs of very low intensity—sounds at and below the threshold of stethoscopic audibility. To accomplish this necessitates a pickup having high sensitivity and wide range, and extremely low levels of ambient noise both in the recording system and in the environment. They have attempted to devise such a pickup. It is essentially a capacitance transducer which does not rely on air conduction of sound and which can utilize the body surface itself as one electrode of the capacitor. Clinical and experimental tests of this capacitance pickup indicate that it is uniquely suited to the recording of cardiovascular sounds.

SESSION 22*

Tues. 2:30–5:00 P.M.

Coliseum
Marconi Hall

DESIGN OF EQUIPMENT RELIABILITY

Chairman: E. J. Breiding, *IBM Corp., Kingston, N. Y.*

22.1. Safety Margins Established by Combined Environmental Tests Increase Atlas Missile Component Reliability

C. C. Campbell, *Convair Astronautics, San Diego, Calif.*

The Convair Astronautics Reliability Test Program is a systematic search for weaknesses in missileborne equipment. All tests are conducted in laboratories which have capability for simulating equipment operating conditions and subjecting the equipment to environmental severities at and beyond those expected in flight. Testing beyond design requirements is done to establish a margin of safety and to create a basis for determining the comparative reliability of all missileborne components. After completing the first three phases of this program, 203 component types, consisting of 980 individual specimens, have been evaluated. This paper will discuss the techniques used in implementing the program, the results achieved to date, and the methods used for effecting corrective action on detected component weaknesses.

22.2. Segregating Subsystem Errors of a Transistor Magnetic Circuit

Walter R. Kuzmin, *Packard Bell Electronics Corp., Los Angeles, Calif.*

This paper describes how a statistical design of experiment was planned to segregate the errors contributed by each subsystem of an electronic circuit composed of the power supply, magnetic cores, and transistorized amplifier. The experiment is described in detail and mentions how small random samples can be utilized efficiently to determine the cause of extreme variability. Upon completion of the experiment, charts are presented which compare the contribution to error by each of the aforementioned individual subsystems. The results also show some startling effects of temperature on magnetic toroids, transistorized amplifier, and power supply.

22.3. The Statistical Analysis of Redundant Systems

Fred Moskowitz, *Rome Air Dev. Center, Rome, N. Y.*

The statistical basis for redundant systems which can be characterized by a probabilistic graph or redundancy network is explored. It is shown that in addition to the more commonly used survival probability function or reliability and its inverse, the cumulative failure probability functions, such related statistical functions as the "hazard," the "safety," and the "mortality distribution" are useful in the statistical analysis of systems. The interrelationship between these functions are discussed and simple formulas are given by means of which it is possible to derive all the remaining functions when one function is known. The use of the exponential, normal, logarithmic normal, and gamma distributions is illustrated and their range of applicability is discussed. Methods are given for deriving or estimating the confidence intervals for given confidence levels of a redundant system when the redundancy network and the confidence interval of the system elements or components are given. In general, it is shown how it is possible to derive the statistical behavior of a redundant system from the statistical behavior of its component parts through the redundancy network and its associated redundancy function.

22.4. Some Results of an Early Reliability Program

Ralph E. Kuehn, *IBM Corp., Owego, N. Y.*

A reliability life test was conducted at several phases of the life cycle of a bombing navigation system to determine compliance with a design requirement of 5000 hours mean time to failure on electron tube modules. Statistically significant results are discussed as well as the cost and economic savings realized by the customer.

The use of a detailed analysis of each component part application and the effect of part modes of failure on system performance are demonstrated by a discussion of relay malfunctions occurring in field operations. Practical and valuable analysis of field failure data is described.

22.5. Maintainability Profile Analysis

H. E. Thomas, J. Soukup, and W. Brobst, *ITT Labs., Nutley, N. J.*

This material presents an evaluating system for specifically quantitizing the maintainability of operating electronic equipment. It seeks to definitize and place measurable figures of merit on equipment designs by establishing a series of key and universal maintainability factors.

When these factors in an equipment undergoing design review are quantitatively applied, they may be represented in a two-dimensional manner upon a histogram type of graph. From a summation of the resultant graph's profile, an average over-all maintainability index may be calculated for comparison and evaluation purposes.

SESSION 23*

Tues. 2:30–5:00 P.M.

Coliseum
Morse Hall

MICROWAVE TUBES

Chairman: Marvin Chodorow, *Stanford University, Stanford, Calif.*

23.1. High-Power CW *X*-Band Amplitron

William C. Brown and Gerald Perloff, *Raytheon Co., Waltham, Mass.*

The platinotron principle has been applied to an *X*-band CW amplitron which nominally operates at 2.5 kw of power output but which has given as much as 8 kw of power output.

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* Sponsored by the Professional Group on Reliability and Quality Control. To be published in Part 6 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Groups on Electron Devices and Microwave Theory and Techniques. To be published in Part 3 of the 1960 IRE International Convention Record.

The tube operates at an efficiency in excess of 50 per cent over a bandwidth of at least 3 per cent. The gain of the device is in the range of 10–13 db. In addition to being the first high-power CW application of the platinotron principle, the tube makes use of new techniques for handling anode and cathode dissipation which greatly extend the power handling capability of the continuous-cathode crossed-field device.

23.2. High-Power *L*-Band CW Traveling-Wave Tube Amplifiers

R. Strauss and J. McCammon, *Sperry Electronic Tube Div., Gainesville, Fla.*

During the past few years advances have been made in the field of high-power (300 watts) CW traveling-wave tube amplifiers. This paper presents the results of a comprehensive development and refinement program on two complementary tube types. The mechanical and electrical characteristics of both types are presented. The design concepts are described. Included in the discussion will be some novel characteristics pertaining to harmonic power generation and the effects of load on tube operation.

23.3. The Effects of Magnetic Focusing Fields and Transverse Beam Velocities on Spurious Oscillations in Backward-Wave Oscillators

Loren L. Maninger, *Sylvania Products Inc., Mountain View, Calif.*

One of the major problems encountered in backward-wave oscillators is spurious oscillation. These oscillations appear to be of the form $nf+m(f+\Delta f)$, occurring on both sides of the main carrier. Theoretical considerations have shown that spurious oscillation is effected by magnetic fields and transverse electron motion. These effects have been verified experimentally on tubes in which transverse magnetic fields and transverse beam velocities have been introduced. The results of these experiments on spurious oscillation level, the ratio of the starting currents of spurious oscillation to the main mode starting currents, beam transmission and power output are presented. The proper selection of design parameters should result in minimized spurious conditions.

23.4. The Design and Performance of a Commercial Ammonia Maser Oscillator

S. Hopfer, *Polytechnic Res. and Dev. Co., Inc., Brooklyn, N. Y.*

Some of the numerous engineering problems associated with the design of a completely self-contained 12×19 inch rack-mounted ammonia maser oscillator will be discussed. In particular, the practical solutions to the problems of cavity pulling, line shape, Doppler shift, maser tuning, and maser sealing-off will be discussed. The RF circuitry associated with the utilization of the ultrastable maser signal, as well as other auxiliary equipment included in the design for safe maser operation will be described. The paper will conclude with a presentation of performance data obtained from three maser models.

23.5. Extended-Dynamic-Range Traveling-Wave Tubes

J. Kliger and E. J. Downey, *Hughes Aircraft Co., Culver City, Calif.*

The "successive-signal-removal" principle has been used successfully in the past to increase the dynamic range of intermediate-frequency amplifiers and of traveling-wave tube amplifiers having video outputs. A brief review of the principle and its application is followed by a résumé of recent work done to increase the range of traveling-wave tubes operating entirely at the microwave level. Increases in input-saturation levels of about 20 db have been realized in experimental *S*- and *X*-band amplifiers. These increases have resulted in dynamic ranges between 60 and 70 db in 15-db noise figure tubes. The small-signal gains of the devices were about 20 db. Design principles and the potentialities and inherent limitations of the method are discussed.

SESSION 24*

Tues. 8:00–10:30 P.M.

Waldorf-Astoria
Grand Ballroom

PANEL: ELECTRONICS—OUT OF THIS WORLD

Chairman: Ernst Weber, *President, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.*

24.1. Intergalactic Data

L. V. Berkner, *Associated Universities, New York, N. Y.*

24.2. Weather Forecasting and Control

Admiral L. deFlorez, *USNR, Englewood Cliffs, N. J.,* and M. Tepper, *Meteorological Satellite Programs, NASA, Washington, D. C.*

24.3. Reconnaissance—Radio, Radiation, Infrared, Optical

Col. B. S. Pulling, *Deputy for Radiation Warfare Support, WPAFB, Ohio.*

24.4. Design for Survival (Personnel and Material)

H. Strughold, *School of Aviation Medicine, Brooks AFB, San Antonio, Tex.,* and T. C. Helvey, *Radiation, Inc., Melbourne, Fla.*

24.5. Communication Relaying

W. H. Radford, *Mass. Inst. Tech., Cambridge, Mass.,* and J. R. Pierce, *Bell Telephone Labs., Murray Hill, N. J.*

The panel includes many of the nation's leading experts in space technology. The members will review current and future demands which will be made upon electronics as our knowledge and the use of space advances.

SESSION 25*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Starlight Roof

DETECTION THEORY AND APPLICATIONS TO PHYSICS

Chairman: Peter Elias, *Mass. Inst. Tech., Cambridge, Mass.*

25.1. Estimation of Doppler Shifts in Noise Spectra

Peter Swerling, *The RAND Corp., Santa Monica, Calif.*

A sample function of a stationary Gaussian process $\{N(t)\}$, having zero mean, is observed for a finite time. The power spectrum of $\{N(t)\}$ is assumed to belong to a family of functions $\{F_h(\omega)\}$, where $F_h(\omega)=F[\omega(1+h)]$, and $F(\omega)$ is a specified even, non-negative, square integrable function of ω. The problem is to estimate h.

Formulas are derived for the mean and variance of estimates belonging to a certain class of estimates of h. Modifications of these formulas are given for the case where $F(\omega)$ is imperfectly known.

An illustrative numerical example is given. A possible application to space flight navigation is pointed out.

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* Sponsored by the Professional Groups on Space Electronics and Telemetry, Nuclear Science, Medical Electronics, and Aeronautical and Navigational Electronics. To be published in Part 5 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Information Theory. To be published in Part 4 of the 1960 IRE International Convention Record.

25.2. Optimum Coincidence Procedures for Detecting Weak Signals in Noise

Jack Capon, *Federal Scientific Corp., New York, N. Y.*

Previous investigators have found the optimum coincidence detector for particular detection problems by a point-by-point graphical procedure. Here it is shown that if the signal is weak compared to the noise, an analytic method can be used to determine the optimum coincidence detector. This method is based on Pitman's concept of asymptotic relative efficiency. The optimum coincidence procedure is compared to the optimum Neyman-Pearson observer. In the case of envelope detection of a sine wave in narrow-band normal noise, it is shown that the optimum coincidence procedure requires a signal-to-noise power ratio only 0.955 db greater than the optimum Neyman-Pearson method requires.

25.3. A General Theory of Signal-to-Noise Improvement, with Application to the Visual Detection of Weak Signals

Norman S. Potter, *The W. L. Maxson Corp., New York, N. Y.*

A new theory of signal-to-noise ratio improvement through readily implemented techniques is developed. It is applied to an empirically derived statistical model of human observer response to weak signals in noisy environments. An optimal postdetection operator, which is a function of the probability density functions of signal-plus-noise and noise alone, operates on the detector output prior to the display generator to maximize the contrast value of the signal to the mean surround. The technique is shown to yield large improvements in detection probability. The theory is applied to several highly recurrent models of signal and noise.

25.4. Information Rates in Photon Channels and Photon Amplifiers

Thomas E. Stern, *Dept. of Elec. Engrg., Columbia University, New York, N. Y.*

A discrete "photon channel" is studied. The maximum entropy source under an average power constraint is determined. The transmission rate through a channel with Poisson signal and additive Poisson noise is calculated and compared to that for an additive Gaussian channel. The two are shown to be similar in the "continuous" region and to differ in the "quantum" region.

These results are applied to amplifiers. It is shown that the communication efficiency of a "physically ideal" amplifier of the maser type operating at 0°K approaches 50 per cent asymptotically for large average numbers of photons and zero asymptotically for small numbers of photons.

25.5. An Aspect of Information Theory in Optics

Hideya Gamo, *IBM Res. Center, Yorktown Heights, N. Y.*

One of the most characteristic features of optical systems is that the nature of optical images is dependent upon various conditions of illumination, namely, coherent, partially coherent, and incoherent illumination. By using the response function, sampling theorem, and intensity matrix for optical images, the limit of resolution among neighboring objects is shown to be essentially the same under various conditions of illumination. The amplitude and phase information of an object under various conditions of illumination, derived by using the elements of intensity matrix for images, which can experimentally be determined, is also discussed.

SESSION 26*

Wed. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Astor Galley

BROADCAST AND TELEVISION RECEIVERS

Chairman: W. L. Dunn, *Admiral Radio Corp., Chicago, Ill.*

26.1. Reduction of Modulation Defocusing in Television Picture Tubes

Joseph Hoehn, *Allen B. DuMont Labs., Clifton, N. J.*

A principal factor causing deterioration of picture quality in a television display is the effect of spot blooming on the highlights. This effect is caused by the increase in space charge repulsion in the electron beam at high currents. An increase in space charge results in an enlarged spot diameter under optimum focused conditions and, of even greater significance, the electron lens must be made stronger to achieve optimum focusing. Thus, under fixed focus conditions, as in all commercial TV sets, the electron spot is both enlarged and defocused at high beam currents.

A reduction in this modulation defocusing has been achieved through the design of a special prefocusing system that is formed in the region of the screen grid. The prefocusing field acts to control the rate of growth of beam diameter with increasing current in a proportion necessary to compensate for the increased force of repulsion (space charge).

26.2. Recent Developments in Scan Magnification

N. Parker, I. Csorba, and N. Frihart, *Motorola Inc., Chicago, Ill.*

A brief review of the concept of scan magnification and the known ways by which it can be accomplished in a cathode-ray picture take is given. The idea of the negative lens in electron optics is discussed and the use of this type of lens in electron beam refraction is described. The paper will include a development of the relationships in negative electrostatic lenses which describe the magnitude of scan magnification and the effect on spot size. The considerations are given for such potential problems as secondary emission, lens distortions, and raster shadowing. The physical problems in the construction of a cathode-ray tube which provides scan magnification are described. The paper will conclude with a demonstration of an operating television picture tube incorporating a scan magnifier.

26.3. Noise Figure Performance of VHF Transistors and Tubes at Various Operating Conditions

J. F. Bell and L. E. Matthews, *Zenith Radio Corp., Chicago, Ill.*

A noise figure measurement technique which quickly yields first-stage noise figure and gain is described. The results of such measurements on a variety of VHF transistors are presented as contours or constant noise figure and constant gain on the collector current-voltage plane. A comparison of similar measurements on vacuum tubes is given.

26.4. A New High-Performance AM/FM Transistorized Portable Receiver

B. J. Miller and E. A. Snelling, *Zenith Radio Corp., Chicago, Ill.*

A description of a transistorized AM/FM receiver embodying new circuit features which include AFC, combined AM/FM IF strip, efficient AGC, and an RF stage optimized for both AM and FM.

26.5. Filter-Phaser AM Stereophonic Receiver

A. A. Goldberg and A. Kaiser, *CBS Labs., Stamford, Conn.*

This describes a receiver for a system of stereophonic broadcasting, which employs conventional amplitude modulation for $L+R$ and quadrature suppressed carrier sidebands for $L-R$.

An envelope detector is used to demodulate the $L+R$ signal and a synchronous detector, the $L-R$ signal. An IF half-lattice crystal filter extracts the carrier for reinsertion at the synchronous detector. The carrier phase shift through the crystal filter is used to control the frequency of the local oscillator by means of a closed servo loop. Squelch circuits are unnecessary because of the absence of a carrier oscillator.

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Problems connected with the matrixing of the L and R signals as well as with RF, IF bandwidths are reviewed.

26.6. A New Concept in Transistor Converters

L. Plus and R. A. Santilli, *RCA, Somerville, N. J.*

This paper describes a method of obtaining an improved AGC characteristic in transistorized broadcast-band receivers. This improvement is made possible through the use of a new device developed specifically for this application. This device may be used in any transistorized broadcast-band receiver, but it is particularly advantageous when an RF stage is not used. Several typical circuits using this new device are presented, and their AGC characteristics are compared with the AGC obtainable with conventional techniques.

SESSION 27*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

ELECTRONIC COMPONENT PARTS

Chairman: Gilbert B. Devey, *Sprague Electric Co., North Adams, Mass.*

27.1. An Evolution Is Coming

Richard Dewitt, *DSDD R & E, The Pentagon, Washington, D. C.*

New concepts of performing electronic functions have been exploding throughout the electronics industry. Many of these have merit; some will fall by the wayside. All have one thing in common—they represent dynamic and progressive thinking. We as engineers will have to become conversant with these new ideas, watch their progress, and be flexible enough to utilize those that will enhance our technological position.

Many enthusiastic proponents claim that our present concepts and efforts are obsolete. Do not become alarmed, just prepare to adapt or develop these concepts to your work as the technology advances. In other words, be alert to take advantage of the advancing state of the art.

These new concepts are known by many names: microminiaturization integrated components, complex components and many others. These names will be examined and analyzed.

27.2. Tomorrow's Technology—Functional Electronic Blocks

Col. William S. Heavner, *Wright-Patterson AFB, Ohio.*

The feasibility of functional electronic blocks and their present status in the molecular electronics program will be discussed. Functional electronic blocks (FEBS) are units of material grown, developed, and/or processed to perform basic electronic operations such as amplification, detection, and switching. How FEBS are being developed to satisfy the various functional requirements of advanced Air Force electronic equipment will be examined, examples will be given, and actual photographs will be shown.

The impact of this new technology on electronic component parts manufacturers will be considered. The future role and position of these manufacturers in the molecular electronics program and their possible contributions towards solving some of the current problems will be brought out.

Some thinking will be generated regarding the future employment of FEBS as inventory items for use in equipment developments vs the independent development of blocks for specific equipments utilizing molecular electronic technology. Example: The system engineer in conjunction with his molecular electronics team may want to design his own solid block of molecular electronics rather than put together the FEBS available from the inventory. The available FEBS may not completely satisfy the system requirements for frequency, stability, etc.

27.3. Electronic Progress —Circa 1960

Col. L. J. D. Rouge and G. M. R. Winkler, *U. S. Army Signal R&D Lab., Ft. Monmouth, N. J.*

The frequent reference to the "galloping technologies of our day" is aimed at the flood of new concepts, devices, techniques, and materials pouring out of organized electronic research and development. In this connection, the Army's newer contributions in the fields of quartz crystal research, thin film capacitors, microwave ferrites, tiny reed relays, solid circuit devices, magnesium batteries, new cathode techniques, kilomegacycle "micro-mesa" and multiwatt "macro-mesa" transistors, etc., are significant parts of this vigorous stream of progress in electronics. This survey paper will discuss and illustrate these and other recent highlights of the Army components and materials R&D programs.

27.4. The Thermionic Integrated Micro-Module Program

C. G. Childs, A. P. Haase, M. W. Hamilton, and R. M. Hughes, *General Electric Co., Owensboro, Ky.*

In recent years component developments have made possible rapid progress in electronic circuit microminiaturization. Engineers of the General Electric Company have developed a new approach to compact efficient electronic circuitry which employs tiny thermionic tubes and specially developed resistors, capacitors, and other elements. Recognizing that as circuits are made more compact (at any given power handling capability) the natural result of increasing power density is increasing temperature, Thermionic Integrated Micro-Modules (TIMMS) have been designed to operate at 600°C. This temperature is achieved by surrounding the microminiature electronic components with suitable high-temperature insulation to contain the power dissipated in the tubes and resistors. Thus, the electrical power supplied to this type of circuitry is used very efficiently. The new electronic tubes and circuit elements are made from ceramic and metal parts particularly suited for high-temperature operation and are brazed together into stacks which yield a component density in the order of 10^6 components per cubic foot.

This paper reviews the design concepts mentioned above and presents an up-to-date report on the component development work which is being carried on at General Electric. Performance characteristics of these components and some of the TIMMS application considerations will also be covered.

This work is still in the developmental phase. Several applications of TIMMS circuitry have been considered in detail and have posed interesting electrical and thermal design problems. This paper will discuss the design approach to the solution of one of these problems to illustrate a method of solution found to be usable.

Thermionic Integrated Micro-Modules are not only small physically, but can be operated at low input voltages completely compatible with current transistorized circuitry. The speed of response of these vacuum tube circuits is very high. Many of the electrical connections required by the electronic function are made within the stack arrangements. Additionally, all the components, both passive and active, are evacuated and continuously gettered and are radiation tolerant, which makes them particularly suited for missile and other military device applications. The necessary thermal enclosure can be constructed in a number of different ways to optimize for minimum over-all system weight or volume as the circumstances require.

This basically new form of microminiature electronics is becoming an important new approach to the solution of the many limitations imposed by the power handling and temperature restrictions of solid-state devices. This paper should serve as an introduction to the TIMMS concept of electronics.

27.5. Microcircuitry—A Practical Technology for Reliable Microminiaturization

F. P. Granger, Jr. and J. G. Smith, *Varo Mfg. Co., Inc., Garland, Tex.*

Microcircuitry is the technology for fabricating complex electronic circuits directly from fundamental particles, eliminating components and connections. Microcircuitry research into fundamental properties of matter and the means of combining molecular particles to obtain any predetermined transfer function is progressing toward ultimate reliability, minimum size, and minimum cost of electronic devices.

The present state of the art of microcircuitry permits the design and fabrication of a wide variety of reliable devices with effective parts densities of from one to ten million parts per cubic foot.

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* Sponsored by the Professional Group on Component Parts. To be published in Part 6 of the 1960 IRE International Convention Record.

SESSION 28*

Wed. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Sert Room

SPACE TELEMETRY

Chairman: DONALD M. CULLER, *ITT Labs., Fort Wayne, Ind.*

28.1. A Versatile Data Processing Facility

J. P. RANDOLPH, *Johns Hopkins University, Silver Spring, Md.*

A highly versatile data processing facility has been established at the Applied Physics Laboratory, Johns Hopkins University, for use in the Navy Polaris, Terrier, Tartar, and Talos missile programs.

The data processing equipment accepts as inputs PAM, PDM, PCM, and FM-FM telemetry information, as well as certain forms of non-telemetered digital systems data. These data are processed as necessary for graphical display, analog computer, or entry into a Remington Rand 1103A computer.

Semiautomatic digitizers are used to translate film and strip-chart data to IBM cards for entry into an IBM 650 computer. Two X-Y plotters operate automatically from IBM cards.

28.2. Evaluation of Modulation Methods for Telemetry Usage

M. RUDIN AND D. CHILDERS, *Aeronutronic Div., Ford Motor Co., Newport Beach, Calif.*

Methods of telemetry systems evaluation and comparison are presented from the standpoint of operational requirements and information theory, and related to the results of laboratory experiments. Optimization of each of four systems of particular interest (PAM-FM, PDM-FM, PCM-FM, FM-FM) is described briefly. It was found in some cases that the systems as commonly adjusted are not optimum and that significant performance improvement is attainable.

Comparative merits of the four systems are presented for varying accuracy by means of optimized performance charts, and the crossover between analog and digital systems is demonstrated and explained qualitatively. The theoretical efficiency of a hybrid, variable accuracy system is discussed on the basis of maximum spectrum utilization and minimum requirement on received power, consistent with the ability to accommodate a wide range of user requirements.

28.3. Conceptual Design of a General-Purpose Telemetry System

W. F. LINK, *Aeronutronic Div., Ford Motor Co., Newport Beach, Calif.*

A broad and general study of the telemetry field, particularly problem areas and means for improvement, has been concluded. This program was tri-service sponsored and had as a primary objective a comparison of modulation methods to find the basic system best suited to handle the bulk of user requirements at the primary test ranges. It was found that most modulation methods which have been used offer one or more salient advantages for a specific application, but a new system is proposed which will be optimum or nearly so for the great majority of user needs. Specifications of parameters and experimentally determined performance of the conceptual system are given.

28.4. Detection Levels and Error Rates in PCM Telemetry Systems

A. V. BALAKRISHNAN AND I. J. ABRAMS, *Space Technology Labs., Inc., Los Angeles, Calif.*

Space and missile telemetry systems employing PCM-FM and PCM-PM are analyzed to determine optimal detection criteria and associated error rates as a function of relevant system parameters. Results are presented in both analytical and graphical form to aid in system optimization. A feature of the analysis is that the usual admittedly inaccurate assumption that the noise is additive and Gaussian in the decision circuitry has been avoided. In particular, exact first-order statistics of the demodulated FM and PM outputs are determined here for the first time. The implications of the results to the communication efficiencies of these systems are also discussed.

28.5. A Highly Precise FM/FM Telemetering Device

HOWARD K. SCHOENWETTER, *Hoover Electronics Co., Timonium, Md.*

Vernitel is a precision device which makes possible the transmission of data with high accuracy over standard existing FM/FM telemetering systems.

The heart of the Vernitel is a special quantizer which converts the input signal voltage into two voltage components—a quantized voltage and a vernier voltage—whose sum is equal to the input voltage. After quantization the voltage components are amplified and fed to two standard FM subcarrier oscillators.

At the receiving station the corresponding voltage components are obtained from two standard FM discriminators and recombined according to simple rules to form the original input signal.

The Vernitel was designed to operate under severe missile and aircraft environment and will normally result in an accuracy improvement of 8 to 10 times that obtainable with standard FM/FM equipment.

SESSION 29*

Wed. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Grand Ballroom

SEMINAR ON 1959 ITU GENEVA CONFERENCE

Master of Ceremonies: F. C. DE WOLF, *Dept. of State, Washington, D. C.*

Chairman: COMMISSIONER T. A. M. CRAVEN, *FCC, Washington, D. C.*

Panel Members: COMMISSIONER R. HYDE, *FCC, Washington, D. C.;* E. A. ALLEN, *FCC, Washington, D. C.;* G. G. GROSS, *Secretary General, ITU;* A. L. LEBEL, *Dept. of State, Washington, D. C.*

From August, 1959 to January, 1960, a world-wide radio conference was held in Geneva under the aegis of the International Telecommunication Union to review and revise the regulations governing the international allocation and utilization of the radio spectrum. The inside story of this important conference will be presented by a panel of leading participants.

SESSION 30**

Wed. **10:00 A.M.–12:30 P.M.**

Coliseum
Faraday Hall

COMMUNICATION SYSTEMS DESIGN

Chairman: EUGENE D. BECKEN, *RCA Communications, Inc., New York, N. Y.*

30.1. Equipment Configuration and Performance Criteria for Fully Optimized Tropospheric-Scatter Systems

CHARLES A. PARRY, *Page Communications Engineers, Inc., Washington, D. C.*

The optimum system is examined with the aid of a basic equation related to channel signal-to-noise ratio. It is shown on this basis that

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* Sponsored by the Professional Groups on Antennas and Propagation, Broadcasting, Communications Systems, Space Electronics and Telemetry, and Vehicular Communications. To be published in Part 5 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

** Sponsored by the Professional Group on Communications Systems. To be published in Part 5 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

FM receivers incorporating new circuit techniques are likely to be superior to SSB systems. Performance equations for such receivers are used in basic expressions developed for optimized scatter systems, to express channel capacity as a function of distance and power. From this, suggested equipment configurations for various performance capabilities are developed.

It is suggested that performance criteria should be based on six tandem links, and limiting requirements are outlined. Difficulties in the measurement of thermal noise are discussed. It is believed that a suitable approach is to specify single link performance in terms of a distribution obtained with one- to two-minute averaged samples.

Data are developed for the transmitted spectrum as a function of channel capacity, and for minimum system bandwidth.

It is finally considered that the limiting performance in multilink circuits may be determined by distortions introduced by multipath effects including selective fading.

30.2. Multifold Diversity Combining Techniques

R. T. Adams, *ITT Labs., Nutley, N. J.*

Present troposcatter communications systems make use of diversity to combat Rayleigh fading and protect against equipment failure. Dual or four-fold diversity is conventionally used.

Recent work using angle diversity has shown that it is possible to exploit troposcatter transmission at much higher microwave frequencies than previously thought possible. In order to use large antennas, however, both the transmitting and receiving patterns make use of multiple beams, requiring the use of very high degrees of diversity. In order to make effective use of signals received on each of several receiving antenna beams from each of several transmitted beams, upward of 10- to perhaps 100-fold diversity will be needed in a typical X-band angle-diversity system.

Combiner requirements for multifold diversity are somewhat unconventional. In combining large numbers of signals, there is a distinct threshold advantage in predetection combining. Cost and complexity of the combining equipment are more important considerations; reliability of individual channels becomes less important, but failures affecting the whole receiver require higher reliability.

This paper describes circuits and techniques suited for multifold diversity combining, including several presently used combining circuits, and an experimental predetection combiner designed specifically for this application.

30.3. Simple Methods for Designing Troposcatter Circuits

Leang P. Yeh, *Page Communications Engineers, Inc., Washington, D. C.*

This paper describes some simple methods, derived primarily from experimental results with occasional reliance on theoretical calculations, in the design of troposcatter circuits based on signal-to-noise ratio for voice transmission and character error rates for teletype transmission.

Appropriate curves are provided for the determination of path loss with special considerations on the frequency and distance dependences of scatter loss, aperture-to-medium coupling loss, correction factors due to terrain and climatological effects, and other circuit parameters such as transmitter power, antenna size, etc. Bandwidth limitation by the medium and various diversity schemes to improve reliability are briefly described.

Circuit reliabilities for single- or multiple-hop systems determined from long-term, short-term, or combined fading distributions are discussed in great detail.

30.4. Optimized SSB Transmitter Loading by Multichannel Frequency Division Data

A. T. Brennan and J. P. Daly, *Stromberg-Carlson Div., General Dynamics Corp., Rochester, N. Y.;* and B. Goldberg, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*

When multichannel radioteletype information is fed to single-sideband transmitters, common practice dictates that momentary transmitter overload be permitted only infrequently, if at all, in order to reduce the effects of intermodulation distortion. To avoid instantaneous overload, the average transmitter power is consequently rather drastically reduced with attendant increases in the error rate at the receiving terminal due to the lower signal-to-noise ratio.

This paper relates the number of information channels simultaneously transmitted by such systems to the degree of distortion generated and to the effect on the error rate at the receiving site. The trade-off between intermodulation distortion at the transmitter and message error rate at the receiver is discussed in some detail.

Experimental evidence is compared for two systems, Kineplex and the AN/FGC-29.

30.5. "Quicksilver"—A Long-Range General-Purpose Digital Communications System

Arthur C. Chapman, *Hughes Aircraft Co., Los Angeles, Calif.*

A high-frequency digital communication system using the quantized frequency modulation (QFM) technique is described. Systems design provides for a basic bit rate of 2000 bits per second capable of expansion to 8000 bits per second by means of a concurrently developed phase modulation system.

Peripheral equipment includes provisions for multispeed teletype, facsimile and digitized voice (vocoder) capabilities. Highly miniaturized modular construction techniques are used in both airborne and ground station.

A phase I test system has demonstrated the feasibility of the "Quicksilver" techniques and has pointed the way toward the development of the more sophisticated phase II system herein described.

SESSION 31*

Wed. 10:00 A.M.–12:30 P.M.

Coliseum
Marconi Hall

ASPECTS OF COMPONENT RELIABILITY

Chairman: C. Robert Deeter, *Battelle Memorial Inst., Columbus, Ohio*

31.1. The Reliability of Components Exhibiting Cumulative Damage Effects

George Weiss, *U. S. Naval Ordnance Lab., Silver Spring, Md.*

In this paper we analyze two models for the reliability of components which show the effects of cumulative usage. In the first, particularly applicable to relays, the failure of the component depends on the time of last use. In the second model the component can be in any one of a number of discrete states, the probability distribution of failures depending on the state. In both of these models we find a formal solution for the probability of failure. Even though it is not always possible to find explicit expressions for the failure time distribution, the moments can usually be obtained rather simply.

31.2. Statistical Models for Component Aging Experiments

Joan Raup Rosenblatt, *Natl. Bureau of Standards, Washington, D. C.*

Statistical methods are considered for analysis of experiments in which electronic components (transistors, say) are subjected to controlled "aging" conditions and measured periodically until "failure." A general framework is proposed for probabilistic models representing the results of such experiments. Some techniques for statistical analysis are outlined which permit simultaneous treatment of variables data and "failure" data, and lead to some possible flexibility in the definition of "failure."

The statistical techniques are directed to the problem of estimating the probability of the joint event that 1) the component survives to age T, and 2) the value of a component characteristic remains within specified limits.

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* Sponsored by the Professional Group on Reliability and Quality Control. To be published in Part 6 of the 1960 IRE International Convention Record.

31.3. Statistical Approach to Reliability Improvement

N. P. Demos, *General Electric Co., Schenectady, N. Y.*

The General Electric Capacitor Department designed a program for developing its commercial tantalum foil capacitor into a high reliability component. At the presentation of this paper, a progress report will be given of this Reliability Improvement Program.

This program calls for the development of an in-process data system and of a reliability control system. The in-process data system would:

1) Contain all significant control elements,
2) Integrate all data sources,
3) Include an automatic analytical methodology,
4) Include an automatic presentation methodology,
5) Include a statistical control system.

The reliability control system would consist of the following parts:

1) An accelerated life test,
2) A monitoring system,
3) Normal test-accelerated test evaluation program,
4) Organization of in-process data,
5) Organization of field data,
6) Presentation of methodology.

31.4. Quality Acceptance Measures —ADL vs AQL

George V. Herrold, *Electronic Tubes Div., Sylvania Electric Products, Inc., Emporium, Pa.*

An acceptance sampling philosophy is presented which, in contrast to the familiar AQL measure:

1) Abandons lot-size–sample-size relationships,
2) Provides and clearly defines a choice of risks for both producer and consumer,
3) Permits meaningful evaluation of the isolated lot when a process average does not exist or is unknown,
4) Introduces the concept of discrimination ratio as a guide to sampling plan selection mutually satisfactory to producer and consumer,
5) Makes no provision for tightened or reduced inspection,
6) Offers equivalent plans for both attributes and variables operation.

The quality measure described is called ADL (acceptable defect level). It is the 50 per cent probability of acceptance point on the applicable operating characteristic curve.

Exemplary plans are presented and complete published tables are referenced. Simple short-cut graphic procedures are displayed for the evaluation, derivation, and comparison of ADL plans.

31.5. Accelerated Environmental Testing of Automotive Electronic Components

Frank R. Khan, *Delco Radio Div., General Motors Corp., Kokomo, Ind.*

This presentation discusses the application of accelerated environmental testing to automotive electronic components for the purpose of establishing satisfactory field performance. It specifically describes vibration tests, high and low temperature tests, humidity requirements, and effects of varying input voltages upon components such as transistors, tubes, condensers, resistors, and speakers, as well as the completed receiver. The Delco Radio speaker is selected as an example of applying accelerated environmental testing to a component in which major changes were made in the types of materials specified.

SESSION 32*

Wed. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

MICROWAVE FILTERS

Chairman: Arthur A. Oliner, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

32.1. Band-Pass Microwave Filter Design—A New Method and Its Relation to Other Methods

George L. Matthaei, *Stanford Res. Inst., Menlo Park, Calif.*

A brief review is made of the fundamental principles of the image design method, and of approximate insertion-loss-basis design methods. Exact design methods using Richard's transformation are also briefly outlined. The practical advantages and disadvantages of these various methods are noted. A new approximate method for design on the insertion-loss basis is presented which has advantages of being computationally very simple, yet having good accuracy for anywhere from narrow to wide (2 to 1 or more) bandwidth filter designs. Straightforward design equations and their underlying principles are given for Tchebycheff, maximally-flat (or other) filters using short-circuited or open-circuited stubs, and also for filters using parallel-coupled lines. The responses of a number of filters designed by this new method were determined with a computer, and a Tchebycheff filter with 2.2 to 1 bandwidth was built and tested. All of these trial filter designs were found to have responses in close agreement with their design objectives. The situations in which this new design method meets previously unsatisfied needs are noted.

32.2. Optimum Quarter-Wave Transformers

Leo Young, *Westinghouse Electric Corp., Baltimore, Md.*

The design of uniformly dispersive quarter-wave transformers is a well-explored subject. Common examples are rectangular waveguide *E*-plane transformers, in which the a dimension is kept constant.

In this paper, it is shown that the performance of conventional one-section quarter-wave transformers can always be improved by making the middle section less dispersive than the input and output waveguides, and a formula for the optimum a dimension is given.

The theory was verified experimentally. In this instance, the improved transformer measured 50 per cent more bandwidth than did the conventional one, and was 25 per cent shorter besides.

32.3. Magnetically Tunable Microwave Filters Employing Single Crystal Garnet Resonators

Philip S. Carter, Jr., *Stanford Res. Inst., Menlo Park, Calif.*

Magnetically tunable microwave filters making use of single crystals of yttrium iron garnet for the resonant element(s) have been been studied for possible application as preselectors in receivers. Broad-band coupling structures have been devised which allow tuning over a full waveguide bandwidth and greater. An experimental single resonator filter has been built using half-height *X*-band waveguide which can be tuned throughout the *X*-band frequency range. This filter has the following characteristics: insertion loss varies between 1.5 and 1.0 db from 8.2 kmc to 11.5 kmc; the 3-db bandwidth varies from 16 kmc to 29 mc from 8.2 kmc through 11.5 kmc. An analysis of the coupling between a ferrite resonator and various circuit configurations including waveguide, transmission lines, and loops is presented. Analytical formulas for the external Q_e and the unloaded Q_u of the single resonator filter are given. One interesting new result of this analytical study predicts that the unloaded Q_u depends on the shape of the ferrite. The formula for Q_u shows that, at low *S*-band frequencies, when using yttrium iron garnet, a considerably higher unloaded Q_u should be achieved with a long rod ferrite geometry than with the spherical ferrite geometry.

32.4. Harmonic Calorimeter for Power Measurements in a Multimode Waveguide

Vernon G. Price, *General Electric Microwave Lab., Palo Alto, Calif.*

A new technique has been devised for the measurement of spurious (harmonic or anharmonic) energy in a multimode waveguide in which no restrictions are made on the waveguide load impedance. A calorimeter is employed with an absorptive harmonic filter whose stop band width coincides with either a harmonic frequency or some anharmonic frequency signal propagating in the waveguide. The calorimeter is designed for high-power operation and for absorption of signal(s) of any direction or waveguide mode. Thus, measurement of spurious outputs of high-power tubes can now be made quickly and accurately without recourse to mathematical analysis previously required.

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* Sponsored by the Professional Group on Microwave Theory and Techniques. To be published in Part 3 of the 1960 IRE International Convention Record.

SESSION 33*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Starlight Roof

ELECTRONIC COMPUTERS AND CIRCUIT THEORY: HOW EACH TECHNOLOGY CAN HELP THE OTHER

Chairman: JEAN H. FELKER, *AT&T Co., New York, N. Y.*

33.1. Switching and Memory Criterion in Transition Flip-Flops

D. O. PEDERSON AND D. K. LYNN, *University of California, Berkeley, Calif.*

It is well known that the magnitude and length of the minimum input trigger pulse is closely related to the amount of memory of the flip-flop. A study of this relationship is made in this paper. Any energy or charge storage element or mechanism cannot serve as the flip-flop memory. A criterion in terms of a simple physical argument has been established to determine which storage elements provide the necessary memory function. The minimum amount of memory is determined from an analysis of the initial conditions of the regenerative switching action. Piece-wise linear analysis techniques are used starting from either conventional circuit analysis or from a natural mode analysis. Examples of capacitivity-coupled and inductivity-coupled circuits, including experimental confirmation, are used as illustrations.

33.2. Monte Carlo Analysis of Transistor-Resistor Logic Circuits

Y. C. HO AND W. J. DUNNET, *Sylvania Electronic Systems, Needham, Mass.*

This paper describes a general approach to statistical investigation of properties of complex transistor switching circuits. In particular, we are concerned with the TRL circuits which use resistive coupling between grounded emitter stages to perform the logical NOR function. An important consideration in the design of TRL systems is the propagation delay of pulse signals through various levels of these circuits. A mathematical model of the delay has been constructed which is a complicated function of the circuit variables as well as of the intrinsic parameters of the transistors involved. A computer program was written to simulate the model on an IBM 709. By using measured statistical data of transistor parameters and randomly sampled circuit variables as input, a Monte Carlo analysis of the distribution of propagation delay is carried out. The results were evaluated by means of nonparametric statistics and verified by actual experimental measurements.

33.3. An Analog Computer Nyquist Plotter

E. A. GOLDBERG, *Space Technology Labs., Inc., Los Angeles, Calif.*

In most analog computer simulations of automatic control systems, the simulation is performed in the time domain. However, for stability analysis and system design it is very useful to be able to obtain frequency domain information from the same simulation. This paper describes an automatic Nyquist plotter which can be used for this purpose.

The operation of this Nyquist plotter is based upon a sampling technique. The information is obtained directly in Nyquist form and can be presented on an x-y plotter. The device has been applied to linear (continuous and sampled-data) control systems. With no special techniques, an accuracy of 2 to 3 per cent was easily achieved.

33.4. Smoothing and Prediction of Time Series by Cascaded Simple Averages

R. B. BLACKMAN, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

Theories of optimum smoothing and prediction of time series have been worked out under a variety of assumptions regarding the characteristics of the data. The results of these theories are important insofar as they establish a ceiling and a standard of comparison for actual schemes. In practice, however, attempts to achieve optimum results usually require large numbers of memory slots and large amounts of computation. Several approximate schemes have been worked out to reduce one or the other or both of these practical requirements. The scheme described in this paper is one which was devised to reduce the amount of computation required.

33.5. Synthesizing Minimal Stroke and Dagger Functions

JOHN EARLE, *IBM Corp., Poughkeepsie, N. Y.*

The techniques of the functions tables, theorems of Boolean algebra, and Karnaugh maps are extended to provide synthesizing and minimizing methods for the stroke and dagger functions. This paper describes the transformations among these and more familiar functions.

These methods are applicable to NOR circuits and all AND-Inverter, OR-Inverter type circuits performing these functions.

The work in this paper was completed at the Underwood Laboratories, Hartford, Conn., August, 1958, prior to the author's association with IBM.

SESSION 34*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Astor Gallery

ULTRASONICS ENGINEERING—I

Chairman: WILLIAM P. RANEY, *Harvard University, Cambridge, Mass.*

34.1. Eigen Coupling Factors and Principal Components, The Thermodynamic Invariants of Piezoelectricity

H. G. BAERWALD, *Sandia Corp., Albuquerque, N. Mex.*

Piezoelectricity is represented in thermodynamically invariant description as a phenomenon relating to two distinct forms of reversible energy density present simultaneously. This is largely irrelevant to, and basically simpler than, the customary tensorial description. Each piezoelectric crystallographic class is in general associated with three eigen coupling factors and associated principal strain-stress and field-displacement component sets, representing stationary values of the ratio: elasto-dielectric to self-elastic-dielectric energy density. Depending on crystallographic symmetry, some eigen coupling factors may be zero or equal to each other. The absolutely largest factor is characteristic of the optimum capability of the medium to transduce electromechanical power.

34.2. Piezomagnetic Ceramic Transducers

OSKAR E. MATTIAT, *Curtiss-Wright Corp., Santa Barbara, Calif.*

The mechanical, magnetic, and magnetomechanical properties of a new piezomagnetic ceramic material are described and compared with presently used magnetostrictive material. Piezomagnetic ceramic transducers have negligible eddy current losses and, therefore, a much better magnetoacoustic efficiency than the conventional magnetostrictive transducers.

A comparison with piezoelectric ceramics (barium titanate PZT, etc.) shows that piezomagnetic ceramics exhibit a lower coupling coefficient, yet a higher Curie point temperature. The new material is well suited for high acoustic intensity transducers, and has great advantages for applications at elevated temperatures. Certain compositions of piezomagnetic ceramics have a zero temperature coefficient and a very high mechanical quality factor (up to 5000) which make them excellently suited for resonator elements in electric wave filters.

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* Sponsored by the Professional Groups on Circuit Theory and Electronic Computers. To be published in Part 2 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Ultrasonics Engineering. To be published in Part 6 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

34.3. An Ultrasonic Power Source Utilizing a Solid-State Switching Device

W. C. Fry, *Westinghouse Electric Corp., Pittsburgh, Pa.*

A single *n-p-n-p* switch rectifier or Trinistor device is used in an inverter circuit of unique design to provide simultaneously the 20-kc ultrasonic power and the dc polarization to a spaced lamination magnetostrictive transducer. The inverter utilizes feedback which makes the circuit self-oscillating. This feedback also provides an automatic frequency tracking feature which causes the inverter to be stable at or near the resonant frequency of the transducer and to follow resonant frequency variations caused by changes in transducer loading. Included in this paper are comments on the Trinistor device and its operating characteristics in high frequency service and a detailed discussion of the particular circuit used in the ultrasonic power source.

34.4. Ultrasonic Cleaning Tests for a Variety of Driving Waveforms

R. C. Heim, *Westinghouse Electric Corp., Pittsburgh, Pa.*

In order to determine the relative effectiveness of pulsed and continuous driving waveforms in ultrasonic cleaning systems, a series of cleaning tests was carried out using a soil preparation of aluminum oxide and grease similar to that described by Koontz and Amron in ASTM Special Technical Publication No. 246. These tests show that a pulsed waveform provides better cleaning action only when the average RF power is below two or three watts per square inch of transducer radiating area. Above this level of driving intensity the unmodulated or continuous wave input provides better ultrasonic cleaning for a given exposure time. Information on the sensitivity of the experiment to soil thickness, detergent concentration, and condition of the cleaning solution is included.

34.5. The Effectiveness of Ultrasonic Degreasing as Measured by Radiotracer Techniques

E. L. Romero and H. A. Stern, *RCA, Lancaster, Pa.*

The ability of ultrasonic cleaning to remove radioactive grease from a television-picture-tube cathode was studied by means of a technique in which radioactive stearic acid was applied to the inside of deep-drawn cathode cups. The degree of soil removal was measured after the labeled parts were cleaned in a detergent solution by means of ultrasonic cavitation. Effectiveness of degreasing was studied as a function of the following factors: 1) the addition of ultrasonic energy, 2) the load of parts being cleaned, 3) the "de-aeration" of the load being cleaned, 4) the size of the ultrasonic equipment, 5) the frequency of the ultrasonic equipment, and 6) the input power of the ultrasonic equipment. As a result of this study, a meaningful test and test apparatus were designed for the measurement of the degreasing potential of any ultrasonic cleaning device.

34.6. A Spaced Lamination Transducer for Industrial Use

E. B. Wright, *Westinghouse Electric Corp., Pittsburgh, Pa.*

The spaced lamination transducer, designed primarily for the ultrasonic irradiation of cleaning and electroplating baths, is discussed in detail. Through the use of the spaced lamination technique, good acoustic loading of any magnetostrictive material can be obtained, thereby making it possible to utilize such materials more effectively in an industrial transducer unit. Comments on a variety of active materials and other design variables are included along with experimental data on the spaced lamination device. Final evaluation of relative cleaning effectiveness is made using a specially prepared aluminum oxide and grease soil similar to that described by Koontz and Amron of Bell Laboratories in ASTM Special Technical Publication No. 246.

34.7. An Efficient Low-Cost Ultrasonic Transducer for Use in Remote Control and Carrier Frequency Applications

Frank Massa, *Massa Div., Cohu Electronics, Inc., Hingham, Mass.*

A small, efficient ultrasonic transducer will be described which incorporates a novel vibrating system that includes a specially electroded piezoelectric disk bonded to a second plate. Two basic designs will be discussed, one using the external surface of a rugged, waterproof housing as the radiating surface, and a second which makes use of the resonant mode of a freely suspended vibrating disk. The transducer design permits operation in air at frequencies in the range 15 to 60 kc. At the higher ultrasonic frequencies bandwidths up to about 8 kc are possible, which permits use of the transducer in portable "walkie-talkie" systems using an ultrasonic carrier to replace the radio frequency transmitter.

SESSION 35*

Wed. **2:30–5:00 P.M.**

Waldorf-Astoria
Jade Room

COMPONENT PARTS

Chairman: Robert Ashby, *Autonetics, Inc., Downey, Calif.*

35.1. Magnetostrictive Ultrasonic Delay Lines for a PCM Communication System

D. Aaronson and D. B. James, *Bell Telephone Labs., Murray Hill, N. J.*

A servo operated delay line pad and a temperature compensated delay line memory, both magnetostrictively driven at 1.5 mc, have been used in an experimental PCM communications system. (H. E. Vaughan, "Research Model for Time-Separation Integrated Communication," *Bell Sys. Tech. J.*, vol. 38, p. 909; July, 1959.)

The delay line pad automatically compensates for external delay changes as small as plus or minus 8 mμsec at a rate of 75 mμsec per second. The delay line memory stores 192 bits which are available both serially or in parallel with an access time of 125 μsec. Both applications use the same basic delay lines which consist of a length of 0.003-inch diameter supermendur wire, two tiny solenoids, and a support.

35.2. The Reliable Application of Electronic Component Parts

H. Lane Dudley, *Melpar, Inc., Alexandria, Va.*

Both the selection and the proper use of component parts are the keystones of well-designed electronic equipment. In this paper it will be pointed out that the selection of reliable components, taking fullest advantage of military approved parts, is only the first part of the job. The second part must be handled by engineers familiar with component parts and basic failure rate data—the engineering reliability group.

It must be recognized that most design engineers are not component application specialists and that there are many pitfalls encountered in proper usage. In a field survey of 18,000 avionics equipments conducted by Hughes Aircraft Company and reported in *Aviation Week*, September 30, 1957, it was stated that of 5 million parts installed, 5 per cent were responsible for 55 per cent of all part failures.

To minimize this misapplication problem, the circuit designer should be required to check the performance of the breadboard over the range of temperatures at which it must operate. After the circuit has passed breadboard tests, a basic and derated failure rate should be assigned the circuit by the reliability group. At this time the reliability group automatically checks circuit stresses on components such as peak inverse voltages, dissipation, peak currents, etc. After discrepancies have been ironed out with the design engineers the prototype design is frozen. However, the reliability group should continue to monitor the use of components. After the prototype is built there are many hours of debugging and test. During this period the reliability group should receive a report on every failed part and the type of failure—shorted, leaky capacitor, open, etc. These parts must be identified as to actual circuit placement as well as type, thereby enabling the reliability group to further pinpoint problem areas.

The component failures may often be eliminated by the selection of a component with a higher rating, and in extreme cases circuit redesign is necessary. It is by use of the methods outlined above that a more reliable equipment can be developed through proper choice and use of reliable components.

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* Sponsored by the Professional Group on Component Parts. To be published in Part 6 of the 1960 IRE International Convention Record.

35.3. The Transient Effect in Capacitor Leakage Resistance Measurements

RAYMOND W. FRANCE, *Hughes Aircraft Co., Culver City, Calif.*

The leakage resistance of capacitors as a function of time is a characteristic to be considered in the choice and control of capacitors, especially in many modern military electronics applications. This paper, by the use of transient circuit analysis, shows why most leakage resistance data accumulated in the electronics industry for capacitors are invalid. Valid data can be obtained by using low resistance meters to make such measurements. Valid experimental curves of leakage resistance vs time for thirteen types of capacitors, each type employing a different dielectric combination, are shown; the significance of these curves is discussed.

35.4. Dynamic Temperature Coefficient of Microelement Inductors

G. HAUSER, *RCA, Somerville, N. J.*

The application of ferrite toroids in frequency-dependent circuits requires specification of the inductance stability. In particular, the temperature characteristic of the ferrite becomes an important circuit parameter. Conventional point-by-point measurements of inductance-temperature characteristic do not always reveal deficiencies of the ferrite material. Therefore, a dynamic test procedure was designed to allow an extensive study of the ferrite temperature coefficient. The test equipment produces a continuous chart of the inductance as a function of temperature. The same equipment is also capable of providing graphs of inductance as a function of ac and dc drive, as well as the temperature coefficient of capacitors and tuned circuits. The National Bureau of Standards reference core proved that the dynamic-temperature-coefficient equipment has sufficient accuracy.

35.5. A New Automatic Method for the Design of Low-Voltage Transformers on the IBM 704

DAVID A. FRANKS, *Westinghouse Electric Corp., Baltimore, Md.*

A new technique for designing low-voltage transformers on a high-speed digital computer has been developed and programmed for the IBM 704. The program developed provides for the design of transformers having the following characteristics: 1) N secondary windings, 2) up to N shields, any of which may be wire-wound or foil, and 3) up to three voltage taps on each winding. Cases where N is as large as 10 can be handled successfully. The program produces the manufacturing specifications in a form suitable for reproduction for use by shop personnel in manufacturing the transformer. The paper describes the technique and some of the results obtained from the computer program using the technique.

SESSION 36*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

STEREOPHONIC SOUND REPRODUCTION

Chairman: BENJAMIN B. BAUER, *CBS Labs., Stamford, Conn.*

36.1. Stereophonic Sound Reproduction

HARRY F. OLSON, *RCA Labs., Princeton, N. J.*

This paper presents the following aspects of stereophonic sound reproduction: the fundamental conditions of frequency range, volume range, reverberation and spatial sound patterns required to obtain realistic stereophonic sound reproduction; the reproduction of stereophonic sound in rooms and automobiles; and stereophonic sound systems in the consumer complex.

36.2. Psychoacoustics of Stereophonic Reproduction

R. L. HANSON, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

When one listens to a transient-type signal from two equidistant loudspeakers in free space, he experiences the sensation of a single well-defined source. The apparent position of the source can be altered by adjusting the relative outputs of the two speakers, by delaying the signal from one, or by a combination of level and delay adjustments. If the transient-type signal is replaced by a steady-state single frequency tone, the virtual source is again well-defined and can be changed in azimuth position by altering the speaker outputs as long as the two sources are in phase. However, as one source is delayed, the virtual source becomes indistinct and localization becomes difficult. Tests will be described which indicate that when one listens to a steady-state single frequency tone, as from a pair of sources in free space or from a single source and its images in a room, he experiences the sensation of a well-defined single source only when the resultant time and pressure differentials correspond to those which could result from a single source in free space. This indicates that the apparent position of a steady-state single frequency source in a room bears a rather complex relation to the position of the actual source. Correct localization is dependent on transients in the signal and may be influenced by visual cues.

36.3. Some Considerations in Design and Application of a Compatible Magnetic Tape Cartridge

MARVIN CAMRAS, *Armour Res. Foundation, Illinois Inst. Tech., Chicago, Ill.*

Magnetic tape may be offered in cartridge form at a price competitive with phonograph disks. Cartridges of different sizes are designed either for superior quality or for maximum tape economy. All of these will operate on present-day machines, as well as on automatic designs. A cartridge-changer allows records to be played in sequence. The erase feature offers interesting possibilities for sale of pure music, separate from the sale of cartridges.

36.4. A 1-7/8 IPS Magnetic Recording System for Stereophonic Music

P. C. GOLDMARK, C. D. MEE, AND W. P. GUCKENBURG, *CBS Labs., Stamford, Conn.*

A new magnetic recording and reproducing system has been developed leading to a prerecorded cartridge substantially smaller than other known media. New approaches to the recording and reproducing system, as well as new components, are described.

36.5. Automated Magnetic Tape Cartridge Mechanisms

JOHN D. GOODELL, *CBS Labs., Stamford, Conn.*

Problems relating to the geometry of magnetic tape cartridges are discussed, along with the relative advantages of various solutions. Designs for tape transports and cartridge changer mechanisms are described, together with systems for fully automated programming of all operations.

SESSION 37*

Wed. 2:30–5:00 P.M.

Coliseum
Faraday Hall

COMMUNICATION SYSTEM TECHNIQUES

Chairman: ANATOLE MINC, *Tele-Signal Corp., Glen Cove, N. Y.*

37.1. Analysis of a Phase Modulation Communications System

ROBERT L. CHOATE, *Jet Propulsion Lab., California Inst. Tech., Pasadena, Calif.*

A communication system is analyzed which utilizes phase modulation (PM) and phase detection. The analysis shows that when the total RF power level is significantly above the receiver threshold; a margin of safety exists which may be traded for additional signal-to-noise ratio (SNR) at the demodulated output of the receiver. In this respect the PM system is similar to FM communication systems which utilize an "FM improvement factor." Several examples are presented to indicate the magnitude of the PM improvement factor when the signal is a sine wave variable throughout the audio band, and a novel type of closed-loop phase detector is suggested which is linear over a very wide range of phase angles.

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* Sponsored by the Professional Group on Communications Systems. To be published in Part 5 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

37.2. An Improved Decision Technique for Frequency Shift Communications Systems

Elmer Thomas, *Page Communications Engineers, Inc., Washington, D. C.*

An improved mark-space decision technique for frequency shift systems is discussed. Fading has been observed to be frequency-selective on ionospheric-scatter and high-frequency communications circuits. Conventional decision techniques are shown to result in a high error liability when deep fades occur on either the mark or space frequency. A decision circuit is described, which effects an improvement approximately equal to an extra order of diversity where fading in mark and space frequencies is independent. A theoretical analysis showing the degree of improvement in signal detectability offered by this new technique is given. Experimental data obtained on operating circuits, as well as in laboratory tests, are presented, verifying the theory and demonstrating the practicability of the technique.

37.3. High Sensitive Receiving Systems for Frequency Modulated Wave

M. Morita and S. Ito, *Nippon Electric Co., Ltd., Kawasaki-shi, Kanagawa-ken, Japan.*

This paper presents some methods of improving the sensitivity in an FM receiver. The conventional FM system has a defect called the threshold level. We have improved this threshold level to a great extent by several methods, and reliable communication has become possible even at weak electromagnetic field intensity.

One of these methods is to demodulate the received FM signal after it is combined with a large sinusoidal voltage, and to apply the FM negative feedback technique. Another method is to detect the phase difference between the received FM or PM signal and a large sinusoidal voltage, and also to apply the FM negative feedback technique.

37.4. An Improved Multiplex Voice Frequency Carrier System

Bernard Tennent, *Philips Electronics Industries Ltd., Toronto, Ont., Canada.*

Using newly developed ferrite tone channel filters, discriminators, and oscillators, multiplexing with channels spaced only 85 cps apart has been made possible in a ±30-cps shift system—thereby almost doubling the usual number of available channels in an allotted tone spectrum.

At least 40-db interchannel attenuation is retained, while the 60-cps wide acceptance band is practically flat, symmetrical and stable.

In another application, the above tone units in conjunction with a specially designed steep band stop filter, enable superposition on a voice carrying wire line the facilities of up to 4 telegraph duplex channels. There is a small degradation of the speech intelligence, as only a narrow portion of the voice spectrum is sacrificed.

The audio networks are built with LC-type resonators, in which Q's of up to 1000 have been achieved with recently available high permeability ferrite cores.

A complete operating system is described.

37.5. Model of Impulsive Noise for Data Transmission

Pierre Mertz, *Long Beach, N. Y.*

It has often been found more necessary in the engineering of data transmission systems to consider impulsive noise than conventional Gaussian "white" noise. A model is proposed for the impulsive noise, which describes empirically an amplitude distribution and a time distribution. Because the latter has in experimental work been described principally in terms of error occurrences, the description is translated into these. The notable characteristics of impulsive noise are that at low occurrence frequencies the amplitudes are much larger than for Gaussian noise, and that impulses or errors tend to be more "bunched" than expected from a Poisson distribution.

SESSION 38[*]

Wed. 2:30–5:00 P.M.

Coliseum
Marconi Hall

ANTENNA PATTERN SYNTHESIS

Chairman: Allen S. Dunbar, *Lockheed Missile Systems Div., Sunnyvale, Calif.*

Panel Members: R. C. Spencer, *The Martin Co., Baltimore Md.;* P. A. Bricout, *Emerson Res. Labs., Silver Spring, Md.;* and R. Bickmore, *Hughes Aircraft Co., Culver City, Calif.*

38.1. Derivative Control in Shaping Antenna Patterns

A. Ksienski, *Hughes Aircraft Co., Culver City, Calif.*

An antenna pattern synthesis method is presented for arrays of fixed element spacing that permits one to approximate desired patterns with arbitrarily prescribed error criteria. Thus either smoothness, linearity, or curvature may be specified for certain parts of the pattern. If desired, an equal ripple approximation may also be very closely approached. The method is seminumerical in nature and may involve several perturbations depending on how closely one desires to approach the optimum. Several numerical examples are worked out in detail, and an experimental verification is also provided.

38.2. Some New Methods of Analysis and Synthesis of Near-Zone Fields

Ming-Kuei Hu, *Elec. Engrg. Dept., Syracuse University, Syracuse, N. Y.*

In this paper, the following new methods of analysis and synthesis of near-zone, including Fresnel-region, fields will be presented:

1) A principle of subdivision and methods of near-zone field analysis. This principle makes possible the use of far-field techniques in near-zone field analyses.
2) A near-zone field synthesis method based upon the principle of subdivision. This method bears a close resemblance to the Woodward method of far-field synthesis.
3) A focusing theorem and a second near-zone field synthesis method. This method transforms a near-zone synthesis problem into a far-field problem, therefore any synthesis method applicable in the far-field can also be applied here.
4) Fresnel-region field analysis of a circular aperture. The results are expressed in terms of a class of new functions which are closely related to the Lommel's functions of two variables. Simple method of evaluating such functions will also be given.
5) A second focusing theorem and Fresnel-region field synthesis. The synthesis is also based upon far-field methods.

Examples of both near-zone synthesis methods will be included. Merits of each method will also be discussed.

38.3. Synthesis of CSC^2 θ-Type Antenna Patterns Using Two-Dimensional Surface Wave Arrays

H. W. Cooper and H. R. McComas, *Westinghouse Electric Corp., Baltimore, Md.*

The development and design principles for a unique flat array (0.032 inch thick at Ka band) of nonresonant slot radiators are described. A surface wave of the dielectric image line type is used as a transmission line to excite a transverse array of slot radiators. The procedure for designing an array of this type is outlined, and it is shown that a dielectric image line of the appropriate size has a field in the transverse direction that decays in almost identically the same fashion as the Fourier coefficients of typical shaped beam patterns used for ground mapping. Thus, an array can be constructed which uses identical slot elements in the transverse plane to achieve the proper amplitudes of excitation coefficient. These radiating slot elements are displaced in the longitudinal plane to achieve the required phase coefficient.

Measured radiation patterns of an array 425 wavelengths in the longitudinal dimension and 25½ wavelengths in the transverse dimension are shown which provide excellent agreement with the theoretical curve.

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[*] Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

Shown are curves of theoretical ripple, as a function of the number of terms of the Fourier series used, for antennas whose main lobes are pointed at 3° and 15° below the horizon. The curves show that it is theoretically possible to synthesize a $\csc^2 \theta$ pattern to a tolerance of 0.4 db with an aperture efficiency corresponding to $HPBW = 90/D/\lambda$ as compared with a typical $120/D/\lambda$ for a reflector-type aperture.

38.4. Determination of Optimum Primary Feed Ellipticity Setting to Obtain Circular Polarization from Reflector-Type Antennas

L. J. KUSKOWSKI, *Airborne Instruments Lab., Melville, N. Y.*, AND A. M. MCCOY, *Raytheon Manufacturing Co., Wayland, Mass.*

A problem prevalent in the use of circular polarization feeds for large parabolic or shaped reflectors is the determination of the optimum primary feed peak ellipticity to obtain circular polarization on the peak of the secondary beam. This problem can usually be solved by a "cut and try" method providing that an antenna range which is long enough and free of reflections is available.

However, with very large reflectors, this can become a serious problem. A simpler approach has been developed which requires neither the "cut and try" method nor the considerable range. This method does not require the use of the reflector and is not limited by reflector size.

Experimental results obtained with an X-Band Scale Model Reflector have verified that the above technique is valid and gives excellent results.

SESSION 39*

Wed. **2:30–5:00 P.M.**

Coliseum
Morse Hall

MICROWAVE INTERACTION WITH MATTER

Chairman: WILLIAM W. MUMFORD, *Bell Telephone Labs., Whippany, N. J.*

Panel Members: S. C. BROWN, *Mass. Inst. Tech., Cambridge, Mass.; C. L.* HOGAN, *Motorola Semiconductor Div., Phoenix, Ariz.;* AND H. KROEMER, *Varian Associates, Palo Alto, Calif.*

39.1. Recent Progress in Microwave Beam, Plasma, and Solid-State Devices

LESTER M. FIELD, *Hughes Aircraft Co., Culver City, Calif.*

A comparison will be made in many frequency ranges between electron beam, gas beam, plasma and solid-state devices used for microwave amplification and oscillation. Parametric, maser, and traveling-wave principles, among others, will be described using these media. Optical masers and plasma sources of microwave energy will be reviewed.

Through improvements in electron beam focusing techniques using magnetic or electric periodic focusing and new forms of microwave circuits, unprecedented levels of gain and frequency have been obtained recently.

Comparable improvements in bandwidth, noise figure, temperature of operation, and frequency using the other media will be discussed.

39.2. Microwave Interaction with Plasmas

R. G. BUSER AND P. WOLFERT, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*

The interactions of microwaves and plasmas in both the presence and absence of magnetic fields and the theoretical principles involved are briefly developed. An experimental apparatus was built wherein high-energy plasmas can be produced in a magnetic field for about 50 μsec.

A microwave beam, emitted from a conventional horn antenna, impinges on the plasma. The energy of the beam is divided into four parts: transmitted, reflected, absorbed, and scattered energy. An experimental setup is described that measures the transmitted, reflected, and scattered energies during the production and recombination periods. These measurements give important information about density, collision frequency, temperature, and plasma movement. Several problems of interpretation of these measurements are discussed.

39.3. A New Semiconductor Microwave Modulator

H. JACOBS, F. A. BRAND, AND M. BENANTI, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*, AND R. BENJAMIN, *Monmouth College, West Long Branch, N. J.*

Experiments have been conducted in which semiconductor rods of germanium are inserted in a waveguide parallel to the direction of the electric field. Upon exposure to light or the injection of minority current carriers by means of a *p-n* junction, the conductivity of the semiconductor is changed. The changes in conductivity, in turn, cause variations in the absorption of microwave energy. This effect has been designed into a device which offers a possibility of microwave amplitude modulation. Performance data and design information relating to the role of the semiconductor lifetime, the effects of various types of trapping centers, and other electrical properties will be described.

SESSION 40*

Thurs. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Starlight Roof

ADAPTIVE NETWORKS

Chairman: MARVIN L. MINSKY, *M.I.T. Lincoln Lab., Lexington, Mass.*

40.1. Pattern Recognition with an Adaptive Network

LAWRENCE ROBERTS, *M.I.T., Lincoln Lab., Lexington, Mass.*

Adaptive networks produce an output by means of interconnections and weighted values derived from previous experience. Several adaptive networks have been designed to test practicality of simple noninterconnected networks for use in pattern recognition. The particular networks which will be described are capable of recognizing many patterns or characters with a high degree of probability. These networks use a single layer of neuron-type elements which provide a type of correlation function on the input matrix—a technique which has proved successful in many tests.

40.2. On Predicting Perceptron Performance

R. DAVID JOSEPH, *Cornell Aeronautical Lab., Inc., Buffalo, N. Y.*

Perceptrons are devices intended to simulate a portion of the logic of the brain concerned with perception. The memory of a perceptron is contained in the values of many components. Perceptrons are classified according to the manner in which these values are modified as result of contacts with the environment. Mathematical analyses are available for the three main types of perceptrons which have a logical depth of two. The capabilities of these systems to classify their environment will be presented, as well as those results for systems of greater logical depth that are available.

40.3. The Mark 1 Perceptron—Design and Performance

J. C. HAY, F. C. MARTIN, AND C. W. WIGHTMAN, *Cornell Aeronautical Lab., Inc., Buffalo, N. Y.*

An experimental model of a perceptron has been constructed and is being used to verify earlier mathematical predictions for its type, and to compare its cognitive abilities to those of biological systems. Visual input is provided through a lens and a retina of 400 photocells. Although the machine is too slow for rapidly changing patterns such as real-time speech, sensory modalities other than visual are also possible. Stimulus patterns received by the sensory units undergo a scattered and otherwise complex projection onto the inner, associative network by a system of excitatory and inhibitory electrical connections. Patch panels and flexible controls permit a large number of elementary machine configurations to be studied.

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* Sponsored by the Professional Group on Microwave Theory and Techniques. To be published in Part 3 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Electronic Computers. To be published in Part 2 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

40.4. A Magnetic Integrator for the Perceptron Program

J. K. Hawkins, *Aeronutronic Systems, Inc., Newport Beach, Calif.*

A magnetic circuit possessing storage and output properties resembling those of W-unit memory elements in perceptron systems is described. Stored value is represented by net flux, and can grow or decay by application of pulses corresponding to activity of associated A-units. Readout is accomplished nondestructively by means of a field applied in a direction orthogonal to normal storage flux. The readout voltage is approximately proportional in both sign and amplitude to the net value of stored flux. Present circuits possess storage capacities of plus or minus 100 increments before saturating. Test results and integrator design considerations are discussed.

SESSION 41*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Astor Gallery

CIRCUIT THEORY: CURRENT CONTRIBUTIONS

Chairman: M. E. Van Valkenburg,
University of Illinois,
Urbana, Ill.

41.1. Transfer Function Synthesis of Active RC Networks

E. S. Kuh, *University of California, Berkeley, Calif.*

A general method is found to synthesize voltage transfer functions with complex poles and zeros using RC elements and a practical active device (control source with finite input and output resistances). The active device can be a grounded base or a grounded collector transistor.

The method allows specified load resistance and often furnishes finite source resistance. The over-all network has a common ground and is economical in terms of the number of elements.

41.2. Broad-Band UHF Distributed Amplifiers Using Band-Pass Filter Techniques

Fred C. Thompson, *HRB-Singer, Inc., State College, Pa.*

The principle of distributed amplification has been applied to great advantage in the design of broad-band low-pass amplifiers. However, distributed amplifiers have generally been limited in application to the VHF region. This paper presents a technique for extending the useful operating frequency of distributed amplifiers to above 1000 mc. The technique basically employs planar triodes that are cascade-connected in a distributed band-pass amplifier. In addition, an active input network consisting of one or more grounded grid amplifier stages is used to optimize the amplifier sensitivity and frequency response.

A typical amplifier constructed according to the design theory presented above has a gain of 16 db ±1 db over a frequency range from 500 to 1100 mc. Measured noise figure is less than 10 db.

41.3. A Fourier Series Time Domain Approximation

Douglas R. Anderson, *Hughes Research Labs., Culver City, Calif.*

This paper presents a new method of approximating to the time domain function corresponding to any completely stable system function. Specifically, suppose we have a system function of the form

$$F(s) = \frac{p(s)}{q(s)}$$

where $p(s)$ and $q(s)$ are polynomials with positive coefficients whose zeros are only in the left half-plane and where

$$\deg (p(s)) < \deg (q(s)).$$

Then by asymptotic formulas of Cerrillo one can compute a minimum positive number B such that the corresponding time function is uniformly small for $t \geq B$. And for t between 0 and any A the following trigometric series uniformly approximates the time function:

$$f_A(t) = \frac{\sqrt{2\pi}}{A}\left[\operatorname{Re}(F(0)) + 2\sum_{n=1}^{\infty} \operatorname{Re}\left(F\left(j\frac{n\pi}{A}\right)\right)\cos\left(\frac{n\pi t}{A}\right)\right].$$

Further, convergence of $f_A(t)$ is very fast whenever $\deg (q(s)) - \deg (p(s))$ is at least 4. Thus, in most cases of interest, this method requires fewer operations for the attainment of a given degree of approximations than do the standard methods of Guillemin, Truxal, and Floyd.

41.4. Spectral Measurements of Sliding Tones

W. Gersch and J. M. Kennedy, *School of Engrg., Columbia University, New York, N. Y.*

The problem of specifying the value of the instantaneous frequency of a sliding tone at some instant in time is considered. A sliding tone is defined as a frequency which changes linearly with time. It is assumed that the specification is to be made by using a spectrum analyzer which is the equivalent of a bank of filters whose outputs are measured at a single point in time.

The problem of obtaining spectral measurements is treated by frequency domain considerations. Results are first developed for the spectral density of a finite fixed duration sinusoid of linearly time-varying frequency, from an interpretation of the Cornu spirals. This is referred to as the input spectrum. The response of a filter to a sliding tone is then computed by convolution of the input spectrum with the selectivity characteristics of the filter considered. The filter selectivity characteristic is obtained by Fourier transforming a periodic representation of the filter impulsive response.

This approach to computation of the filtered characteristics of sliding tones illuminates an interpretation of the physically meaningful parameters of the filter and input and facilitates computation of the filtering action. In addition it helps suggest filter characteristics that are desirable from a spectral measurement point of view. Results are presented which indicate the response of a variety of filters to a sliding tone input.

The contribution of the approach presented to the evaluation of the response of filters to sliding tones has two major advantages over earlier efforts:

1) Its usefulness for approximate analysis and the interpretation of the effects of filter and signal parameters,
2) The ease and economy of computation of accurate results.

For completeness, filter responses to a very rapidly sliding tone are discussed from the time domain point of view.

41.5. An Approach to the Synthesis of Linear Networks Through Use of Normal Coordinate Transformations Leading to More General Topological Configurations

E. A. Guillemin, *Elec. Engrg. Dept., Mass. Inst. Tech., Cambridge, Mass.*

The proposed procedure presents a method of determining parameter matrices from given impedance functions through use of normal coordinate transformations, and realizes the pertinent network by identical tree configurations in single-element-kind networks having a general topological structure. Essentially the same procedure is applicable to passive bilateral networks and to nonpassive and/or nonbilateral ones, differing only in the appropriate normal coordinate transformation. Although tedious computations are involved, the availability of modern computers makes this method feasible and thus opens up a more general and potentially useful approach to network synthesis.

SESSION 42*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

ULTRASONICS ENGINEERING—II

Chairman: Warren P. Mason,
Bell Telephone Labs.,
Murray Hill, N. J.

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* Sponsored by the Professional Group on Circuit Theory. To be published in Part 2 of the 1960 IRE International Convention Record.

* Sponsored by the Professional Group on Ultrasonics Engineering. To be published in Part 6 of the 1960 IRE International Convention Record.

42.1. The Measurement of River Flow by the Use of Underwater Sound

G. E. Miller, W. F. Richardson, and N. Serotta, *Raytheon Co., Wayland, Mass.*

A survey of presently known methods of measuring river flow is presented. The results of a study of the use of acoustic signals for the determination of flow velocity are given. Several different acoustic flowmeter systems are evaluated.

This work was supported by the U. S. Department of the Interior, Geological Survey, under Contracts 14-08-001-3993 and 14-08-001-5426.

42.2. Ultrasonic Flowmeter

H. Dahlke and W. Welkowitz, *Gulton Industries, Inc., Metuchen, N. J.*

An ultrasonic flowmeter has been developed which works on the principle of deflection of the sound beam by the liquid stream. An ultrasonic pulse is sent through a pipe transverse to the pipe axis. A receiver transducer which is on the opposite side of the pipe and is positioned on the side of the beam pattern measures the amplitude of the received signal. As the beam is shifted by the flow, this amplitude varies in proportion to the flow. Experimental results indicate that an eight-inch flowmeter can be built with about one per cent linearity for flow rates up to 3000 gallons per minute.

42.3. Optical Studies of Delay Line Transducers

Richard F. Weeks, *Richard D. Brew & Co., Inc., Concord, N. H.*

Our present understanding of the properties of delay line transducers has been largely derived from electrical measurements of delay lines. Unfortunately, it is difficult to separate the effects due to the transducers from those due to the wave nature of the propagation of the signal media by purely electrical measurements. These difficulties can be overcome by measuring the acoustical signal from a transducer with a modified Schlieren system and looking at the transducer "from both ends." The photoelectric apparatus designed to make these measurements is described. It is shown that the ultrasonic field in fused silica may be described by the Fresnel and Fraunhofer diffraction formulas. An expression is derived for the insertion loss due to diffraction effects. Schlieren measurements of the ultrasonic fields are compared to the electrical admittance of several transducers to determine their coupling coefficient and dissipation as a function of frequence. Further studies planned at this laboratory are discussed briefly.

42.4. Ultrasonic Delay Line Analysis

D. L. Shilling and A. N. Silver, *Columbia University, New York, N. Y.*

Based on earlier work by W. P. Mason and H. J. McSkimin, equivalent circuits are presented for the over-all transmission characteristics of an ultrasonic solid delay line. The resultant expressions for insertion loss, bandwidth, and ripple are plotted in terms of the normalized parameters of the piezoelectric transducer, the delay medium, and the electrical termination for 1) a backing material cemented to one face of the transducer, and 2) half-wavelength bonds (seals) cemented between the transducer and delay medium. These normalized curves constitute engineering design nomographs, which facilitate the simultaneous calculation of the insertion loss, bandwidth, and ripple, necessary to satisfy a particular over-all transmission characteristic. It is shown that employing backing materials a maximum 3-db bandwidth of 75 per cent may be achieved, while for a half-wavelength bond whose characteristic impedance approaches that of the delay medium, bandwidths of approximately 55 per cent are possible. In addition, experimental results are given for delay lines utilizing backing materials, and operating at a frequency of 10 mc. In this range, bandwidths of 65 per cent have been obtained, with an insertion loss of approximately 56 db.

42.5. A Comparison of Several Dispersive Ultrasonic Delay Lines Using Longitudinal and Shear Waves in Strips and Cylinders

Arthur H. Fitch, *Bell Telephone Labs., Inc., Whippany, N. J.*

Some recently developed ultrasonic delay lines employing the dispersion of elastic waves in solids possess advantages of cost and size in performing circuit functions heretofore accomplished with lumped parameter electrical networks. Several such delay lines are compared with regard to such features as compactness, versatility, delay-vs-frequency characteristics, and discrimination against unwanted signals.

42.6. Physical Principles and Operational Characteristics of Variable Ultrasonic Delay Lines

Walther Andersen, *Andersen Labs., Inc., West Hartford, Conn.*

Variable acoustic delay lines typically consist of two pieces of fused quartz, each with an acoustic transducer, so designed that as one piece is moved with respect to the other, a variation in delay results. The mating surface of the two pieces of quartz must be very accurately ground, and a special viscous couplant is used between the two surfaces.

Ratio of delay variations as large as 50 to 1 have been obtained.

Principal uses of these devices are:

1) In moving target simulators,
2) In adjustable long delay lines suitable for MTI or integrator applications,
3) In ECM devices,
4) As the control element of stable variable frequency oscillators.

42.7. New Techniques in Ultrasonic Delay Lines

David L. Arenberg, *Arenberg Ultrasonic Laboratory, Inc., Jamaica Plain, Mass.*

The first successful ultrasonic delay lines using multiple symmetry designs were based on regular polygons with a nonprime odd number of sides. Only a few facets were tilted from the regular position and the distance from the center, R_i, adjusted slightly.

To improve on the number of available designs, further investigations were made. Different criteria were used in selecting good designs, the most critical being the minimum aperture of the geometric beam at all the reflections. Maximizing this minimum results in a linear programming involving adjustment of the distances R_i.

Adjustment of all the angles allows an increase in the number of variables and better apertures. This last feature permitted the use of any polygon including prime and even numbers. Delay lines using these new designs have been made and found satisfactory.

SESSION 43*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Sert Room

EQUIPMENT AND SYSTEMS

Chairman: J. A. Eggert, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*

43.1. Missile Master (AN/FSG-1)—System Functional Description

G. Romano, D. L. Prentice, and J. Hayne, *The Martin Co., Orlando, Fla.*

43.2. Missile Master (AN/FSG-1)—System Equipment Description

R. Staschke and D. Noden, *The Martin Co., Orlando, Fla.*

In these two papers, a description of the U. S. Army Missile Master, AN/FSG-1, antiaircraft defense system is presented. This description includes a project history and a review of Missile Master's part in the nation's over-all air defense system. Operational functions and equipment comprising the major subsystems, radar and tracking, tactical display, data communication, and fire unit integration, are described. These subsystems are discussed in terms of the data to be exchanged and the various displays and controls made available to the system's operators and the weapons commander. The integration of the Missile Master system with the U. S. Air Force semi-automatic ground environment (SAGE) and various missile systems, is also discussed.

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* Sponsored by the Professional Group on Military Electronics. To be published in Part 8 of the 1960 IRE International Convention Record.

43.3. Weather Radar Data Processing

D. Lowenschuss, *Budd Lewyt Electronics, Inc., Long Island City, N. Y.*

This paper discusses the development of a radar data processor, used for encoding the intensity and height of the cloud cover over an extended area (44,000 square miles). The processor accepts video signals from a weather radar set, quantizes and averages the data (removing interference from external sources), and displays the data locally. In addition, the processor stores the data, and transmits them at high speed upon demand by the central data processor. The processor is intended for use in the Air Force Weather Observing and Forecasting System 433L, which contains a network of observation stations linked to a central data processing center by a high-speed wire transmission system.

43.4. A Building-Block Approach to Multipurpose Communication Equipment

L. G. Fobes and J. E. Martin, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*; H. A. French, W. L. Glomb, and M. W. Green, *ITT Labs., Nutley, N. J.*

A design approach permitting functional flexibility with optimized performance in multipurpose, multichannel, communications equipment is discussed. Interchange of building block plug-in units would permit transmission to be tailored to 12, 24, 48, 72, 96, or 120 voice channels by PPM, PCM, or FDM in line-of-sight, over-the-horizon, or satellite communications systems in different frequency bands such as 2 or 4 kmc, in vehicular or fixed installations. Control of transmitted and received bandwidth by the use of Gaussian filters is discussed, as is the use of triode doublers to the upper *S*-band region, and IF combining for PCM troposcatter. Modular construction, conservative design, and applied human engineering, can all be combined to achieve a basic equipment design which can be readily modified to achieve the desired operational characteristics for a variety of military tactical situations.

43.5. An Integrated Approach to the Design of Mobile Tactical Electronic Systems

R. N. Skalwold and M. N. Scheiderich, *Rome, N. Y.*

This paper investigates the hypothesis that mobile military electronic systems can be drastically reduced in weight and volume for strategic and tactical mobility if a sufficiently broad systems viewpoint is taken.

The results of the study indicate that such an integrated approach can result in a complete radar system weighing only one third the weight of an extremely advanced lightweight radar system not completely integrated.

43.6. Electronic Equipment Weight and Volume Penalties to Flight Vehicles

William V. White, *Collins Radio Co., Cedar Rapids, Iowa.*

The existence of electronic equipment weight and volume penalties to high-performance flight vehicles is well known, but the means for evaluating the magnitudes of these penalties has not been completely defined. A means for penalty evaluation is presented for several types of aircraft. For existing aircraft, equipment weight and volume penalties are evaluated in relation to their effect upon range and endurance. For proposed flight vehicles, the penalties are evaluated in relation to their effect upon the over-all vehicle gross weight. Weight and volume penalties have been evaluated individually for both types of aircraft. Also, to permit more generalized interpretation, a combined weight and volume penalty analysis is presented. As a result of penalty evaluations, equipment planners and designers will be more aware of the effects of equipment weight and volume upon flight vehicles and will realize the ultimate benefits of equipment miniaturization efforts.

SESSION 44*

Thurs. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Empire Room

SATELLITE COMMUNICATIONS

Chairman: Charles H. Doersam, Jr., *Sperry Gyroscope Co., Great Neck, N. Y.*

44.1. Radio Relaying by Reflection from the Sun

D. J. Blattner, *RCA Labs., Princeton, N. J.*

The possibility of using radio reflection from the sun to provide a communication link supplementing that using moon reflections is investigated analytically. Reflection and absorption of an incident signal in the solar atmosphere, and thermal noise radiated by the sun, are considered together with transmitter capabilities to find the operating frequency giving optimum signal-to-noise ratio. The design principles for a receiver which can separate the signal from the noise are indicated. Finally, achievable signaling rates and reliability are calculated.

44.2. Active vs Passive Satellites for a Multistation Communication Network

L. Pollack and D. Campbell, *ITT Labs., Nutley, N. J.*

The operational world-wide communication system will interlink many countries with widely different traffic requirements.

The use of space stations for relaying traffic in such a system poses the problem of selection of a passive or active satellite.

Among the problems discussed are the interference within the system and to other services, the power required vs message capacity, and the control of traffic.

44.3. Satellite Communication Problems and Solutions in Ground Station Design

W. L. Glomb, *ITT Labs., Nutley, N. J.*, and W. Teetsel, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*

The operational requirements of a low altitude "store and forward" satellite communication system are reviewed and some unique problems defined. Particular problems are reviewed and their solutions described.

In general, this typical satellite communication system is characterized by one station moving at high speed, by intermittent communications, by a limitation in weight, size, and complexity of the satellite with the corresponding burden in equipment and design ingenuity in the ground station, and by communication ranges considerably beyond those encountered on the earth's surface. Designs anticipating these characteristics have been evolved and have been applied to the communication system.

The derivation and application of these designs in the system are discussed in some detail. Their ultimate application in the Army's ACAN system is described.

44.4. Detail Design of an Operational Missile Voice Frequency Communications System

Ward S. Cayot, *Nortronics, Hawthorne, Calif.*

This paper describes a detail design program to develop a voice frequency communication system for use in checking out Snark intercontinental missiles at a two-squadron missile strategic site.

The program is traced from predesign analyses of acoustics problems and questions of speech intelligibility in ambient noise levels of 120 db to the development of a system that coordinates unrelated hot-line interphone, strategic alert, and tie-in telephone subsystems into an integrated, flexible, command and technical communications network.

The paper discusses the selection of intermediate electrical levels, the provision for minimum changes in sound level regardless of the drastic changes in numbers of stations on any line, the design for AVC, and means for carrying overriding public-address-type announcements on all communications channels.

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* Sponsored by the Professional Groups on Space Electronics and Telemetry and Communications Systems. To be published in Part 5 of the 1960 IRE International Convention Record.

44.5. A Digital Data Handling System for Real-Time Computation on the Atlantic Missile Range

M. P. FALLS, *RCA Service Co., Patrick AFB, Fla.,* AND T. A. CHRISTIE, JR., *Stanford University, Stanford, Calif.*

Procurement of improved tracking radar and digital computing devices at the Atlantic Missile Range required development of new high-speed data handling and transmission equipment which would link these devices utilizing existing communication facilities.

The essence of the newly developed equipment is a data transmission system capable of *reliable* 3000-baud operation over a toll-quality carrier voice-channel. Quaternary, pulses are utilized to conserve bandwidth, and reliable FM is the transmitting medium.

The equipment transfers data from a high-precision CW tracking radar, known as AZUSA to an IBM 709 computer used in making real-time calculations of impact and apogee predictions of ballistic missiles. Operating performance data for this type of equipment over typical communications facilities are included.

SESSION 45*

Thurs. 10:00 A.M.–12:30 P.M.

Coliseum
Faraday Hall

HUMAN FACTORS IN ELECTRONICS

Chairman: ROBERT R. RIESZ, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

45.1. Coding Equipment for Ease of Maintenance

J. H. ELY, *Dunlap Associates, Stamford, Conn.*

The purpose of this study was to develop recommendations concerning information to be displayed on prime electronic equipment. Specifically, it was recommended that the following information be displayed (visual aids will be shown to demonstrate each recommendation):

1) Designation of functional groups of equipment,
2) Identification of signal paths,
3) Identification of test points and indication, when appropriate, of sequence in which they should be used, and
4) Presentation of historical data displaying periodic readings taken at each test point when equipment was operating satisfactorily.

45.2. The Replaceable Component: Key to Maintainability

ROBERT B. MILLER, *IBM Corp., Poughkeepsie, N. Y.*

Maintenance consists of checking, adjusting, troubleshooting, replacing, and sometimes repairing.

Replaceable packages or assemblies are the key to first-level maintainability because they determine: essential test points; contents of troubleshooting diagrams and service manuals; troubleshooting strategies and mean fault-location time; accessibility requirements; and nature and extent of training for first-level maintenance personnel.

This is especially true where the basic package is designed with a consistent level of maintenance knowledge requirements in mind. Updating of engineering change information can be simplified. In designing basic packages, therefore, maintainability considerations are worthwhile trade-offs against economy in manufacture and inventory.

45.3. A Procedure for Predicting Reliability of Man-Machine Systems

P. C. BERRY AND J. J. WULFF, *Psychological Research Associates, Inc., Arlington, Va.*

In complex man-machine systems output is not dependent upon the performance of every component since some serve to monitor others and to initiate back-up performance for failure. Such systems may be described as a network of contingent functionings, each function being classified as multiplicative, additive, or shunting. The description must encompass all functions, man and machine, operational and maintenance. Given the probability of adequate function of each, we may calculate the probability that enough will function adequately to produce system output. For human performance, we may calculate the probability of excessive variation from an average performance level by a method analogous to inspection by variables. Once a value of system reliability is obtained, the reliability of a subsystem may be evaluated by its proportionate effect upon total system reliability.

The procedures described were developed under contract with the Burroughs Corporation, Paoli, Pa., and are presented by permission.

45.4. A Method for Anticipating Human Factors Requirements in Manned Weapon Systems

MILTON A. GRODSKY, *The Martin Co., Baltimore, Md.*

The utility and need for human factors information early enough in a weapon system's development are discussed in terms of recommendations for equipment design and training and selection of operations personnel. Various methods of anticipating these requirements are given, particularly those concerned with missile and space systems. A critique of each of these methods is presented and the criteria for an optimum method are given.

A method employing the above criteria is presented and an example of its applicability to a space system is developed. The utility and accuracy of this method is also exploited.

SESSION 46*

Thurs. 10:00 A.M.–12:30 P.M

Coliseum
Marconi Hall

SCANNING ANTENNA ARRAYS

Chairman: CARLYLE J. SLETTEN *AF Cambridge Res. Center, Bedford, Mass.*

Panel Members: J. RUZE, *Radiation Engrg. Lab., Maynard, Mass;* H SHNITKIN, *The W. L. Maxson Corp. New York, N. Y.;* AND A. E. MARSTON, *Naval Res. Lab., Washington, D. C.*

46.1. An Electronically Scanned Circular Antenna Array

H. P. NEFF AND J. D. TILLMAN *Elec. Engrg. Dept., University of Tennessee, Knoxville, Tenn.*

A circular antenna array is described in this paper which has the following characteristics:

1) Any azimuthal pattern can be obtained which can be represented by a truncated Fourier series.
2) The main beam can be pointed to any azimuth angle.
3) The phase of the current in each element and the terminal impedance of each element does not depend on the direction of pointing.

These characteristics make it possible to connect amplifiers to each element, and to control the direction of pointing by varying the magnitude only of the amplifier output. The design of an array of this type and of the required amplifiers is described, and experimental confirmation is presented.

46.2. Multidirectional Antenna—A New Approach to Stacked Beams

JUDD BLASS, *The W. L. Maxson Corp., New York, N. Y.*

This paper describes a new approach to the design of stack beam antenna. The technique utilizes a multiplicity of linear arrays of directional couplers, the outputs of which are connected in series to the radiating elements of a linear array.

It is shown that the coupling between feedlines is at the sidelobe level if the phase distribution in the individual feedline results in a radiation beam divergence of more than one beamwidth. Thus the multidirectional characteristic is obtained from a single linear array such that, when coupled to N input connection, N independent beams are produced.

The design analysis and results of tests of a ten-foot X-band model are described.

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* Sponsored by Professional Group on Human Factors in Electronics. To be published in Part 10 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

46.3. Parasitic Spiral Arrays

R. M. Brown, Jr. and R. C. Dodson, *U. S. Naval Res. Lab., Washington, D. C.*

Arrays of circularly polarized elements have he property that their radiation patterns can e scanned by element rotation since rotation hanges the element phase. This principle has een used in the design of two different arrays f Archimedean spirals, one a "parasitic lens rray" and the other a "parasitic reflector rray."

The lens consists of two arrays of spirals nounted on opposite sides of a conducting lane, each spiral on one side being connected y a transmission line to a corresponding piral on the opposite side. A feed horn is used to illuminate one of the arrays; the energy eceived by this array passes through the ground plane via the transmission lines and is eradiated by the spirals on the far side. If he elements are rotated to particular orientaions, the incident spherical wave can be ocused, and further, the beam can be scanned f the spirals are rotated properly. The passive piral reflector is a single array (using no ransmission lines) mounted above a ground lane and, like the lens, is illuminated by a eed horn. It has the same focusing and scanning properties as the lens. Neither array is imited to circular polarization. With a combination of right- and left-hand elements, inear polarization can be used. Twenty-element lenses (2 by 10) and one hundred-element eflectors (10 by 10) have been built and the esults have verified the predicted performance.

46.4. An Electromechanically Scannable Trough Waveguide Array

W. Rotman, *AF Cambridge Res. Center, Bedford, Mass.*, and A. Maestri, *Melpar, Inc., Falls Church, Va.*

This paper describes an electromechanical rough waveguide array which was designed and constructed to demonstrate the feasibility of a rapid scanning antenna utilizing a traveling-wave trough waveguide feed. The trough waveguide array was used to illuminate a section of a parabolic reflector. The antenna, a linear array, depends on several properties of the trough waveguide. Two methods are described which are capable of electromechanically swinging the fixed beam of a linear array based on the trough waveguide by changing the phase velocity in the guide. The two methods are:

1) Rotation of symmetrical structures within the trough waveguide which have the quality of producing different values of guide wavelength in different orientations.
2) Mechanically varying the height of periodic structures located on the top of the center fin of the trough waveguide.

Both methods were incorporated in short arrays with the latter also used in an array which is 10 feet long. Successful operations with scan angles in excess of 20° have been obtained from both methods.

Experimental data are presented on the 10-foot array feeding a parabolic cylinder.

SESSION 47*

Thurs. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

MAGNETIC RECORDING

Chairman: Marvin Camras, *Armour Res. Foundation, Chicago, Ill.*

47.1. The Effects of Track Width in Magnetic Recording

D. F. Eldridge and A. Baaba, *Ampex Corp., Redwood City, Calif.*

The effects of track width on various performance characteristics have been measured over a wide range of widths. Signal level, noise, and signal-to-noise ratio were determined for track widths from 1 mil to 92 mils. The effects of crosstalk, tape guiding, and actual recorded track width vs head width are described. The experimental data are in good agreement with theory and no serious practical limitations on the use of very narrow tracks are discovered. High density audio and pulse recordings were made without difficulty. Digital bit densities of one million per square inch, and above, are shown to be possible.

47.2. Erased Carrier Recording

William J. Murphy, *Oliver-Shepherd Industries, Inc., Nutley, N. J.*

There are many applications in which it is desirable to record data with a spectrum extending down to dc. One relatively unknown method, called erased carrier or amplitude modulation recording, will be the subject of this paper. A theory of operation will be developed as well as an explanation of the process. Approximate results for a typical system will also be presented. Advantages and disadvantages of such a system will be discussed, as well as some suggested applications.

47.3. Reliability and Drop-Out Studies for Long-Playing Loops

Al Wilson, *Precision Instrument Co., San Carlos, Calif.*

Although the tape loop has been used extensively for repeated playback analysis of selected portions of instrumentation data, there is little complete information available which reflects its performance characteristics after long-term repetitive playing. Because of increased interest in the tape loop technique and the belief that it would become a more useful laboratory tool once operational limitations were known, an exhaustive study was conducted. The effects of basic design, length of loop, tape speed, and type of tape were considered. The reliability under various conditions was measured by counting the number of "drop-outs" (instantaneous loss of signal) on the tape after a specified period of operation. The results of the study are, for the most part, presented in the form of graphs, charts, and statistics.

47.4. Digital Magnetic Recording with High Density Using Double Transition Method

Andrew Gabor, *Potter Instrument Co., Inc., Plainview, N. Y.*

The solution of three major problems in high-density multichannel recording, such as pulse crowding, interchannel time displacement and information drop-out, is discussed.

After a study of these limiting factors, a write-read system with many favorable features is described in detail and results of extensive experimental investigation are given. It is shown that the use of the described techniques offers a storage capacity of 24,000 bits per square inch of tape (1500 bits per inch longitudinal and 16 channels per inch lateral packing density) combined with a character rate of 225 kc at 150 ips tape speed.

Reliability is greatly in advance of conventional parallel recording with comparable density. Drop-out rates better than one bit in 500 million have been observed.

47.5. Automatic Error Detection Equipment for Digital Tape Recorders

G. J. Slusarchyk, T. D. Radway, and P. Heller, *Airborne Instruments Lab., Mineola, N. Y.*

This paper describes a transistorized electronic device for examining the performance of a high packing density, start-stop, spaceborne digital tape recorder.

The equipment described automatically writes preset words at varying rates to full recorder capacity. Upon playback, the recorder's output is electronically examined for skew, effects of wow and flutter, word spacing, word lengths, and word bit content. The error detection equipment provides word error figures for the tape recorder in a readily accessible form without the requirement for additional detailed data evaluation.

This equipment utilizes basic diode logic techniques and digital modules such as transistorized flip-flops and monoshots. Reliability of the error detector circuitry is achieved through self-checking features.

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* Sponsored by the Professional Group on Instrumentation. To be published in Part 9 of the 1960 IRE International Convention Record.

SESSION 48*

Thurs. **2:30–5:00 P.M.**

Waldorf-Astoria
Starlight Roof

ELECTRONIC COMPUTERS

Chairman: JOSEPH J. EACHUS, *Minneapolis-Honeywell Regulator Co., Newton, Mass.*

48.1. An On-Line Solid-State Analog Computer for Automatic Gas Flow Compensation

F. P. SIMMONS, *Link Aviation, Inc., Binghamton, N. Y.*

A completely automatic, solid-state, analog computer is described for continuously solving the basic equation used to calculate quantity rate of gas flow through an orifice for accounting and dispatching purposes. The computer is unique in that it performs multiplication, division, and square root extraction using only two transistorized multipliers in the system. An analysis of the parameters involved in the basic equation is included, which shows that specific gravity, in most natural gas installations, may be considered as a constant and contribute less error in the calculated rate of flow than would be contributed by considering it an independent variable. The paper includes an error analysis of the system along with the scaling method used to program the equation through the computer.

48.2. Very High Density Digital Magnetic Recording

DONALD E. KILLEN, *Oliver-Shepherd Industries, Inc., Nutley, N. J.*

Due to greatly improved heads and media, and the amplitude discrimination and restricted bandwidth of phase modulation techniques, 3000 bits per inch on tape is now possible. Operation is reliable near the noise level. Noncontact densities approach 500 bits per inch, due also to special low-loss drum and disk coating techniques. Other recording methods, (*e.g.*, *RZ*, *NRZ*) rely on high signal-to-noise ratio, and are therefore not compatible with high information density. A systems approach is tantamount to achieving high density; heads, media, and electronics must be carefully integrated. One proposed tape system would achieve a 1-mc character transfer rate at moderate velocity, for direct input to computer without buffering.

48.3. A Tunnel Diode Tenth Microsecond Memory

M. M. KAUFMAN, *RCA, Camden, N. J.*

A resistor load line placed across a tunnel diode (negative resistance diode) produces a two stable state storage unit. There have been tunnel diodes made to oscillate above 3 kmc indicating the high-speed capabilities of the above storage unit.

A type of tunnel diode memory cell believed to be practical for a large (approximately 10^8 bits) memory has been developed. The memory cell is a baseband destructive "read" type with a resistor loaded tunnel diode and a transformer coupled output. The cell has been chosen on the basis of its simplicity and relatively large magnitude of output signal. The large magnitude of output is achieved with the transformer coupling and is very significant at the tenth microsecond memory speeds.

Packaging techniques have been developed for the memory cells which produce large packing densities and maintain the proper electrical properties at a reasonable cost.

A theoretical and laboratory study has been made of memory cell and distributed memory matrix parameters with an attempt to specify optimum parameters.

An 8×8 bit plane with the over-all dimensions and selection lines dummy loaded to simulate a 32×32 bit plane has been built and successfully tested in the laboratory.

48.4. Automatic System and Logical Design Techniques Used on the RW-33 Computer System

T. A. CONNOLLY, *Thompson-Ramo-Wooldridge Inc., Los Angeles, Calif.*

Techniques to improve and aid logical and system design are discussed. These techniques shorten the development cycle by verifying the design before the equipment is assembled. The method eliminates many costly logical revisions and decreases system checkout and integration time. The main technique discussed is the logical simulation package. Secondly, integration of the logical and instruction simulators which improves both logical and system integration is discussed.

48.5. Logical Design Features of the Larc System

W. F. SCHMITT AND L. F. HARRISON, *Remington Rand Univac, Philadelphia, Pa.*

The logical structures and operations of the several Univac®-Larc system elements are described. The overlapped control cycle and major arithmetical operations of the computing unit are outlined. The memory unit logic and system synchronization are described. The Univac-Larc Input-Output Processor is described briefly with particular emphasis upon the input-output circuitry and the input-output dispatcher. A brief account is given of the logical elements employed in the design of the system.

SESSION 49*

Thurs. **2:30–5:00 P.M.**

Waldorf-Astoria
Astor Gallery

SYMPOSIUM ON A DECADE OF PROGRESS IN NETWORK THEORY

Chairman: H. J. CARLIN, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

49.1. Graph Theory and Electric Networks II

FRANK HARARY, *University of Michigan, Ann Arbor, Mich.*

Some of the open problems mentioned in the article, "Graph Theory and Electric Networks" (IRE TRANSACTIONS ON CIRCUIT THEORY, vol. CT-6, pp. 95–109, March, 1959) have since been solved by various authors Other results which exploit graph theoretic methods for applications to the combinatorial aspects of electrical network theory have recently appeared. These articles deal with the following topics: 1) Boolean functions and synthesis problems, 2) the spanning trees of a network, 3) the realizability of cut set matrices 4) the consistency of precedence matrices, and 5) finite automata. A progress report will be presented emphasizing latest developments.

49.2. Physical Realizability Criteria

D. YOULA, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

A rigorous theory of linear, passive, time-invariant n-ports is surveyed from an axiomatic point of view. The notions of linearity, passivity, time-invariance, and causality are defined precisely for the most general operator which maps n-dimensional vector functions into n-dimensional vector functions. One main result is that with the exception of certain pathological cases, linearity and passivity imply causality. Moreover the causality postulate plays absolutely no role in a theory of linear, passive networks.

Some of the physical implications of Maxwell's equations when applied to dielectric media are also discussed, particular emphasis being placed on the construction of nonreciprocal structures.

Lastly an algebraic treatment of lumped active metworks is outlined which includes both the analysis and synthesis problems.

49.3. Some Properties of Time Varying Networks

J. M. MANLEY, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

In this paper, the general theory of reactance amplifiers is exemplified, with attention centered on three aspects. 1) Why may gain be obtained from a nonlinear reactance and not from a nonlinear resistance? 2) Where there is gain and feedback, the possibility of oscillation exists. But the situation is more complex than it is with vacuum tube amplifiers because the feedback path is through the modulator so that an external impedance at one frequency may be reflected as an impedance at another frequency. 3) The particular case of three frequencies, *e.g.*, p, q, p-q, is calculated for large signals. The phenomena of regeneration and oscillation, with subharmonic oscillation as a special case, are studied and illuminated.

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* Sponsored by the Professional Group on Electronic Computers. To be published in Part 2 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Circuit Theory. To be published in Part 2 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

49.4. Application of Synthesis Techniques to Electronic Circuit Design

FRANKLIN H. BLECHER, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

During the past decade, considerable progess has been made in the field of RC-active etwork synthesis. Techniques are now availble for realizing a wide range of driving point nd transfer characteristics. This work is exremely important since it defines the region f theoretical possibilities. The question rises, though, as to how useful this synthesis heory is for practical circuit design. Active ircuit elements such as negative impedance onverters and feedback amplifiers using solidtate devices can be designed to have the same tability as the best passive circuit elements. Infortunately, however, the nature of present ynthesis techniques is such that the resulting C-active networks are more sensitive to both assive and active circuit element variations han in the case of passive RLC networks.

Some of the more useful active network ynthesis techniques will be reviewed and comared from the points of view of generality, ensitivity, and numbers of passive and active ircuit elements required to realize a given netvork function. It will be shown that at frequencies below about 30 kc, RC active netvorks are competitive with all other methods f filter design. Finally, two of the synthesis echniques are used to realize a twelfth-order qual-ripple Tchebycheff parameter band-pass lter centered at 18 kc.

SESSION 50*

hurs. 2:30–5:00 P.M.

Waldorf-Astoria
Jade Room

SPACE ELECTRONICS

hairman: PAUL POLISHUK, *Wright Air Dev. Center, Wright-Patterson AFB, Ohio*

50.1. A Broad-Band Spherical Satellite Antenna

H. B. RIBLET, *Johns Hopkins University, Silver Spring, Md.*

The design criteria and results of the design f a broad-band spherical antenna are disussed. The parameters of design and their ffect on radiation patterns are briefly invesigated. The particular antenna was developed rom an equiangular spiral slot plotted on a lane and then projected on the surface of a phere. Attention is given to problems of isolaion and matching when the antenna is used or multifrequency operation. The particular ntenna discussed is being used in the Transit atellite program.

50.2. A Pulsed Plasma Mechanism for Propulsion in Space

P. M. MOSTOV, J. L. NEURINGER, AND D. S. RIGNEY, *Republic Aviation Corp., Farmingdale, N. Y.*

A *variable* wall-resistance as well as a constant source-resistance are included in the analysis of a plasma accelerator. Coupled *nonlinear* equations involving 7 parameters are derived. This formulation is more realistic than Artsimovitch's treatment (source, wall-resistance zero) and Shock's approximate *periodic* mode treatment (wall-resistance zero). Curves of position, velocity, efficiency, utilization, instantaneous efficiency, voltage, current, and instantaneous frequency are given. Periodic and aperiodic modes, as well as mode-switching and *switch-backs* are shown possible. In one typical case, including source-resistance lowers efficiency from 100 to 30 per cent; including wall-resistance further lowers it to 22 per cent. Practical optimization of utilization by terminating at local peaks can frequently be achieved with reasonable tube lengths.

50.3. Design Considerations of Television Satellite Reconnaissance Systems

R. L. ZASTROW AND D. J. RITCHIE, *Bendix Aviation Corp., Detroit, Mich.*

The following applications of satellite television reconnaissance are briefly considered; weather reconnaissance, shipping and ice patrol forestry surveys, mapping and military reconnaissance. The coverage, frequency of observation, grey scale rendition, and resolution requirements for each application are discussed.

Television systems using vidicons and image orthicons are compared. The sensitivity, resolution, dynamic range and spectral response of the vidicon and image orthicon are discussed. The design parameters of a television system (frame rate, picture format, band-pass, number of lines per raster) are analyzed and related to system requirements for resolution and coverage. The influence of optical design parameters such as field-of-view, distortion, focal length and relative aperture is analyzed in terms of system requirements.

The information content of a television picture is defined. The power and bandwidth required to transmit the video signal to a ground station is analyzed for different methods of encoding the telemetry carrier. The use of a tape recorder aboard the satellite, and the problems of obtaining sufficient bandwidth and recording capacity are discussed.

50.4. Scanning Methods for Satellite-Borne Radars

A. ROSENFELD AND O. LOWENSCHUSS, *Budd Lewyt Electronics, Inc., Long Island City, N. Y.*

This paper is concerned with scanning methods suitable for use in earthward-looking satellite-borne search radar systems. Particular attention is given to the case of a pencil-beam radar borne by a polar-orbit satellite. The corresponding airborne case is analyzed, and the need for special methods in the space-borne case is explained. Methods are then considered which make maximum use of the translational and rotational motions of the satellite to aid in effecting the scanning process. The advantages and disadvantages of such methods are examined in some detail.

50.5. A Study of Natural Electromagnetic Phenomena for Space Navigation

R. G. FRANKLIN AND D. L. BIRX, *The Franklin Inst., Philadelphia, Pa.*

A study has been carried out for the United States Air Force investigating the use of natural electromagnetic radiation in the space environment for navigational purposes. Radiations from the sun, the stars, and interstellar space in both the visible and radio frequency portions of the spectrum, and cosmic rays have been investigated.

Emphasis has been placed on the measurement of velocity in space utilizing the Doppler phenomenon. Equipment and techniques useful in deriving velocity information from Doppler shift measurements are described and figures for expected accuracy are derived. Other passive techniques having possible application to space navigation such as the measurement of total solar radiation and solar diameter are touched on briefly.

SESSION 51*

Thurs. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

CHECK-OUT INSTRUMENTATION AND CIRCUITRY

Chairman: DR. J. Q. BRANTLEY, *Radiation, Inc., Orlando, Fla.*

51.1. Trends in Complex Weapon System Checkout

F. C. COREY, *Nortronics Div., Northrop Corp., Hawthorne, Calif.*

Methods of checkout that will be used in testing the electronic portions of complex weapons systems and space vehicles from 1963 to 1970 are described and key factors affecting the choice of manually operated, semiautomatic, or completely automatic equipments are discussed. Relative advantages of externally programmed test equipment controlled by tape or cards vs internally programmed test equipment controlled by digital computers, magnetic memories or stepper switches are evaluated. Methods of mechanizing equipment to give more than "go, no-go" answers are described and a high-speed, computer-programmed digital system using magnetic drum memory storage is proposed.

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* Sponsored by the Professional Group on Space lectronics and Telemetry. To be published in Part 5 f the 1960 IRE INTERNATIONAL CONVENTION ECORD.

* Sponsored by the Professional Group on Military Electronics. To be published in Part 8 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

51.2. The Role of Multipurpose Automatic Test Systems in Testing Integrated ABNMGS Systems

Dr. Ibrahim H. Rubaii, *IBM Federal Systems Div., Owego, N. Y.*

To assure the continuing satisfactory operation of a complex bombing-navigation and missile guidance system, extensive efforts must be expended in the testing process, which depends heavily upon the test system. In this paper, the testing process and test systems are treated in analytical fashion. The test system is divided into basic functional elements that are universal to all test systems. These functional elements, or subsystems, are then integrated into a *theoretical automatic multipurpose test system.* Boundary conditions imposed on this general system would lead to any special purpose test system.

51.3. Selecting the Optimum Test Interval for Static Alert Systems

F. Paulsen and L. Mast, *Packard Bell Electronics, Los Angeles, Calif.*

A method was found for determining the best frequency of tests applied to static alert systems such as missiles. Two mathematical models are established in which the best test frequency is expressed in terms of cost, failure rates, duration of test, and down time due to maintenance or repair. Conclusions include that:

1) The most economical arrangement requires that the test frequency be less than the test frequency which gives maximum operational readiness.
2) In general, different test frequencies are appropriate for different tests. Therefore, the current practice of establishing a "test sequence" and performing all tests at the same test intervals should be critically examined.

51.4. Rapid Detection of Coherent Signals in Noise

R. J. Metz, J. M. Walker, and N. L. Weinberg, *Westinghouse Electric Corp., Air Arm Div., Baltimore, Md.*

A method is described of detecting coherent signals in noise based on noncoherent integration allowing rapid signal detection in a multichannel receiving system. This is accomplished by time-sharing the outputs of each of the channels with a common detection criterion. To eliminate problems incident with time sharing a large number of conventional RC integrators a mechanization is described which uses square loop magnetic cores to perform all required functions. The noncoherent integration function is performed by the accumulating action of the core.

The results of this investigation are presented as curves of probability of detection vs signal-to-noise ratio. An evaluation is made between magnetic core detection and RC detection.

51.5. Determination of Repetition Frequencies of Intermixed Pulse Trains

Ronald J. Kern, *RCA, Camden, N. J.*

The problem of determining the pulse repetition frequencies contained in a composite signal received from a large group of pulsed transmitters is discussed. This problem, which arises in connection with military reconnaissance receivers used to determine the PRF of enemy radars, is complicated by the wide range of PRF's encountered, the high degree of measurement precision required, and the unknown number of transmitters present.

Two methods of PRF determination under the stated conditions are presented in this paper. The first method involves time domain autocorrelation while the second method consists of a network of cascaded delay lines, the delay of each being a function of position in the network. Mathematical analysis and practical mechanization techniques are presented.

51.6. Coherent Enhancer for Pulse Radar Applications

E. Brookner and J. Flink, *Federal Scientific Corp., New York, N. Y.*

The ideal matched filter with many delay lines is difficult to implement. Thus, rather than use the ideal filter, a technique which approximates the ideal matched filter was devised consisting of a single delay line loop which is much simpler to implement. In addition to extending the range, the matched filter will provide Doppler velocity information and also has the features of an MTI.

The matched filter is compared against the more common video integrator. It is shown that the range extension capabilities of the matched filter are superior.

SESSION 52*

Thurs. **2:30–5:00 P.M.**

Coliseum
Faraday Hall

VEHICULAR COMMUNICATIONS

Chairman: R. P. Gifford, *General Electric Co., Lynchburg, Va.*

52.1. Past and Future Techniques of Vehicular Communications

E. W. Chapin, *FCC, Laurel, Md.*

A résumé will be made of the development of vehicular communications, starting with the pre-electric age and pre-wireless age. The general history of the early wireless communication to moving vehicles will follow and comparisons will be made between the characteristics of the early radio-telephone equipments and later types, with respect to both the improvements which increased the utility of the equipments and those improvements which permitted more efficient use of the radio frequency spectrum. Tabulations will show the changed technical characteristics over the years. These characteristics will cover: crystal harmonics, spurious harmonic problems, frequency stability, and bandwidth problems.

Possible approaches to obtain still more efficient utilization will be discussed as well as considering newly available components and equipments which may increase the need for more facilities. For example, the availability of really portable transistorized equipment may tend to develop a whole new field of communication similar in scope to the land-mobile communications systems presently so widely established. In some instances, this new expansion will undoubtedly be integrated with present systems, but, in other cases, combination with landmobile operation may not be involved.

52.2. Radio Coverage—Area Survey—Instrumentation Research

C. E. Sharp and R. E. Lacy, *U. S. Army Signal R & D Lab., Fort Monmouth, N. J.*

The rapid establishment of effective short-range radio communications is of the utmost importance in modern Army operations. Due to the over-occupancy of the lower frequencies, the need to use the UHF and SHF bands for short-range communications has become imperative. The higher frequency bands also have the advantage that vehicular antennas of small physical size can have high gain and directivity.

Transmission between terminals in the higher frequency bands is normally limited to radio line-of-sight. The usual methods for determining whether transmission is possible between selected terminals are time consuming and inconclusive. Path loss prediction methods have been devised for various types of irregular terrain; while these methods predict the average expected value, however, for any given path the deviation may be as much as plus or minus 30 db.

Investigations at the U. S. Army Signal Research and Development Laboratory of survey system using a combination of radar and photographic techniques have indicated strong possibilities for a rapid and effective means of determining all possible satisfactory short-range communication paths from any given location with an antenna height above ground equal to the average vehicular antenna. The survey system involves making a composite photograph of a mobile radar plan position indicator and map of the area centered at a given location with careful attention to orientation and scale factors. Areas on the composite photograph from which terrain backscatter is evident, with some simple considerations, can readily be determined as satisfactory terminals for communication circuits.

Interest in this survey system stemmed from the need for rapid siting of point-to-point vehicular radio communications employing directive antennas. This interest has led to an extensive experimental investigation of numerous backscatter map overlays in all conceivable types of terrain. The purpose of this investigation was to establish definitely for all types of terrain the correlation which exists between the terrain backscatter return points and he actual measured path loss to these points. Four representative frequencies were chosen in he range 1200 to 9000 mc for the actual path measurements. A standard mobile Army surveillance type radar equipment operating at 1300 mc was used in making the map overlays. An average of twenty minutes is required to produce a map overlay. A correlation has to be established between the system gain of the vehicular equipment and system gain of the radar. This means that in general the system gain of the radar must be reduced in order to match the system gain of the communication equipment. This is most simply done by adjusting a calibrated gain control on the radar receiver. The adjustment must take into consideration the type terrain in the area surveyed. Illustration of map overlays will be shown in various terrain situations for distances up to en miles.

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* Sponsored by the Professional Group on Vehicular Communications. To be published in Part 7 of the 1960 IRE International Convention Record.

52.3. Cryptographic Signaling Applied to Radio Communication Circuits

Owen E. Thompson, *Secode Corp.,*
San Francisco, Calif.

The primary concern of this paper is a discussion of a system wherein multiple, *secret* messages may be delivered to any one of many receiving locations on a radio circuit.

Present day one-way signaling (paging) systems will be discussed sufficiently to develop the historical background and establish the need for a system with both secrecy and multiple message capacity. The degree of secrecy of this system is inherently very high and will be discussed in detail. The basic system code capacity of 31 discrete messages, at any one of many receivers (actual capacity of system is many thousands of receivers) will be discussed.

Equipment description will be facilitated by display of actual working units. Part of the system employs standard Secode multiple unction decoders of the same type that have been in industry-wide use for the past few years. Other portions of the system that are of recent development will receive the major portion of time allotted to equipment description.

In addition to system concept and technique of implementation, specific types of application will be discussed to illustrate the wide field of need that will be satisfied by this system.

52.4. Highway Alert Radio

E. A. Hanysz, *General Motors Corp.,*
Warren, Mich.

The author's laboratory recently released the news of the development of a new roadside-to-vehicle communications system utilizing voice-modulated, sub-10-kc carrier, electromagnetic induction radiation. The purpose of this system is to introduce a voice message into the passing vehicle regarding road conditions, detours, exists and emergency situations directly ahead so that the driver is alerted to react wisely. Reports received from highway and traffic engineers seeing this system have been glowing and it appears that such communications will find widespread acceptance n the near future.

This paper discusses the development of portable transistorized transmitters and receivers, the problems attendant in modulating a sub-10-kc carrier at audio frequencies, temperature stabilization, antennas and patterns, and circuits for muting the standard car radio. The author is also entertaining the idea of bringing a complete system with him (since it is portable) and demonstrating it to interested parties.

52.5. A New Colinear Antenna Array

A. H. Secord and W. V. Tilston,
Sinclair Radio Labs., Ltd.,
Toronto, Ont., Canada

In order to serve ever-expanding communities it has become necessary in recent years to develop omnidirectional antennas with higher and higher gains. These antennas serve the need for the mobile base station and for repeater stations.

This paper describes the application of a special phase changer which when periodically distributed along a cylindrical conductor controls the phase of the radiating currents and so concentrates the radiation in a plane, perpendicular to the axis of the cylindrical conductor.

SESSION 53*

Thurs. **2:30–5:00 P.M.**

Coliseum
Marconi Hall

ANTENNA AND PROPAGATION PROBLEMS

Chairman: Jack Herbstreit, *Natl.*
Bureau of Standards,
Boulder, Colo.

53.1. Spiral Antenna Systems

R. Bawer and J. J. Wolfe,
Aero Geo Astro Corp.,
Alexandria, Va.

The basic purpose of this paper is four-fold:

1) To place the spiral antenna in its proper perspective with regard to what may be reasonably expected from these antennas in practical situations.
2) To present experimental data compiled from many antennas operating under a wide variety of conditions.
3) To interpret these results in light of the band theory.
4) To emphasize those aspects of parameters which significantly affect the operation of the antenna.

All of the spirals described have capability for accurately scaling from one frequency band to another. None of the spirals are plagued by the beam lobing with frequency and polarization; all spirals have zero boresight error. Excellent circularity is obtained not only on the peak of the beam but also throughout the spiral beam to the tenth power point. The data are presented to indicate how these units are superior to existing designs and how they can be easily reproduced by the antenna designer interested in an element covering 2 to 1 frequency band with superior pattern, polarization and impedance performance.

53.2. A Monopulse Cassegrainian Antenna

L. Schwartzman and R. W. Martin, *Sperry Gyroscope Co.,*
Great Neck, N. Y.

The Cassegrainian antenna has become increasingly useful for radar systems application. A summary of the design considerations employed in selecting a Cassegrainian antenna, rather than a conventional antenna with the feed at the focal point, are presented. The application of the Cassegrainian antenna described here is for monopulse systems. For a chosen illumination of the secondary aperture, greater latitude in the choice of the actual feed horn dimensions is afforded by a Cassegrainian antenna. Design equations describing the basic parameters are included. The range- and angular-sensitivity functions which are of prime importance in a monopulse design are developed. Curves depicting their behavior as a function of horn size and F/D ratio are included. The near-field problem which arises if the main reflector is substantially less than 100 λ, is discussed along with methods of eliminating these effects. Experimental data are presented and compared to the theoretical predictions.

53.3. Power-Handling Capability of Antennas at High Altitude

W. E. Scharfman and T. Morita,
Stanford Res. Inst.,
Menlo Park, Calif.

The factors influencing the power-handling capability of antennas at high altitude are considered in this paper. The physical mechanism involved, including the roles of attachment, free diffusion, ambipolar diffusion, and nonuniform field distribution in the breakdown process, is qualitatively described. These factors are illustrated by breakdown curves for various antenna configurations under both CW and pulse conditions. Normalized data, which are useful for estimating breakdown fields when the conditions for scaling are fulfilled, are presented. Methods are then considered for increasing the power-handling capability, and typical results are given showing the increase in power that can be achieved.

The effect of missile environment on breakdown characteristics is discussed, and an experiment that involves artificially introducing ionization near the surface of the antenna is described.

53.4. Propagation Measurements in Shock-Ionized Media

D. E. Sukhia and G. H. Hampton,
The Martin Co.,
Baltimore, Md.

This paper presents the results of propagation experiments conducted in Hot Shot II, a hypersonic wind tunnel at AEDC in Tullahoma, Tenn. The experiments consisted of simultaneous transmission of L and X band and S and X band emissions through the electron plasma generated in the Hot Shot tunnel. The receiving antennas were immersed in the plasma inside the tunnel. The observed results are compared with theoretically computed values and the limitations of this technique are outlined. The experimental results tend to verify the theoretical estimates of the deleterious effects of the hypervelocity sheath. These results, along with Fastax movie records of the glow from the shock, will be presented.

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* Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1960 IRE International Convention Record.

53.5. Ultra-Low Frequency Atmospherics

HERBERT KÖNIG, *Electro-Physical Inst., College of Tech., Munich, Germany.*

It was possible to establish by measurement that in the frequency range from 0.5 cps to 25 cps, electrical signals are present in the atmosphere whose origin is not trivial.

At that occasion the existence of electromagnetic oscillations was proved with a frequency of about 9 cps. The origin of these signals probably lies in flashes of lightning which excite the resonator earth-ionosphere to oscillate in its basic frequency, thus creating signals whose conditions for spreading are very favorable.

Besides, various electrical field variations of a more local character were observed. These signals probably were connected with certain weather conditions.

In addition to an occurrence during sunrise which probably was caused by processes during the development of the ionosphere in its daily structure, the measurements showed a few other electrical and magnetic special forms whose origin is unknown.

53.6. Ray Tracing for Whistler-Mode Signals at Low Frequencies

E. R. SCHMERLING, *Pennsylvania State University, State College, Pa.;* R. GOERSS AND S. MILUSCHEWA, *RCA, Hightstown, N. J.;* AND P. HERTZLER AND I. PIKUS, *RCA, Camden, N. J.*

A number of whistler-mode ray-paths have been traced in an IBM 650 computer using Haselgrove's equations. A frequency of 5 kc was taken at a geomagnetic latitude of 50° for various initial propagation angles. A centered dipole was used for the earth's field, and a simple ionspheric electronic-density model based on Seddon's (1957) composite curve. The purpose of the work was to examine the path spreading as a function of initial angle, not to obtain the exact conjugate points, so that the simple model was considered adequate. This problem has a special bearing on second-hop signals and satellite-originated signals, since signals originating on the ground are not expected to have a large spread of angle at heights of the order 100 km. A decided shift of the downcoming rays towards the equator was found, and a large spread of the order 1000 km for the angular spectrum.

SESSION 54*

Thurs. **2:30–5:00 P.M.**

Coliseum
Morse Hall

WAVEFORM ANALYSIS AND RANDOM VARIABLES

Chairman: MICHAEL DI TORO, *Polytechnic Res. and Dev. Co., Brooklyn, N. Y.*

54.1. A Time-Compressor Using Magnetostrictive Delay Lines

S. J. MEYERS, L. ROSENBERG, AND A. ROTHBART, *ITT Labs., Nutley, N. J.*

Waveform analysis of low-frequency signals may be simplified by storing a given time segment of the signal, and then transferring this segment to a higher frequency band. The stored signal, which may be read out repeatedly many times faster than the speed of original storage, is transformed into a time-compressed repetitive waveform. It is then available for analysis during a time interval equal to that of the input signal.

This paper will discuss the design principles and test results of an experimental time-compressor which used magnetostrictive delay lines as the storage mechanism. The signal segment, 1/20 second duration, was bandwidth limited to 1500 cps. Within the compressor, pulse code modulation (PCM) was used to transmit eight analog levels in a reflected binary code. The low-frequency sampling rate was 4 kc and the compression factor was 200.

54.2. Utilization of the Quadrature Functions as a Unique Approach to Electronic Filter Design

HENRY PARIS, *Rixon Electronics, Inc., Silver Spring, Md.*

This paper describes a new approach to electronic filter design used to obtain a tunable band-pass filter in the audio spectrum. The method consists of utilization of the quadrature functions described by Dr. D. K. Weaver in the December, 1956 Single Sideband Issue and employs modulation, frequency translation, low-pass filtering, and phase cancellation to achieve a band-pass filter, with a variable center frequency, and a translated output range. The quadrature function theory is described in detail, both diagramatically and mathematically, through the use of slides.

A few of the obvious applications of the system are discussed; however, the presentation is in as broad a manner as possible to eliminate restriction of the design approach to the present Rixon application and to enhance stimulation of ideas for improvements and new applications for the quadrature function design approach.

54.3. A Magnetostrictive-Filter Random Wave Analyzer

RICHARD BOYNTON, *MB Electronics, New Haven, Conn.*

A new type of Audio Frequency Random Wave Analyzer presented in this paper contains two desirable features previously only available independently: rapid analysis time and narrow bandwidth scanning. Utilizing a parallel bank of narrow-band magnetostrictive rod filters and an unique solid-state circuit to translate each aperiodic signal filter output to a dc level, this instrument permits measurement of stationary sources as they occur. Currently available single-filter sweep frequency analyzers offer scanning bandwidths as narrow as 2 cps but require over half an hour to analyze a single random input. Increasing this sweep rate necessitates wider bandwidth scanning, resulting in an erroneous smoothing out of peaks and notches in the spectral density curve.

54.4. A Numerical Method for Determining the Vibration Acceleration Density Directly from the Sinusoidal *XY* Plot

W. REICH AND M. SCHNEE, *American Bosch Arma Corp., Hempstead, N. Y.*

The acceleration density at a point on the vibration table, fixture or specimen may be obtained by processing a tape recording of the random acceleration at that point with an automatic wave analyzer. This paper describes a method to obtain the same information using only the standard equipment on the MB T88 Random Motion Console.

The advantages of this method are:

1) The tape recorder and wave analyzer may be used elsewhere.
2) Time required is only twenty minutes compared to two hours using the tape and analyzer.
3) The acceleration density may be predicted without actually subjecting the equipment to random vibration.

54.5. A New Approach to Random Vibration Control Instrumentation

WILLIAM W. CALDWELL, *Ling-Altec Electronics, Inc., Anaheim, Calif.*

Equalization, applied to random vibration testing, is the process of generating a continuous function, the complement of that of the shaker plus load measured at the shaker mounting point, so that the net frequency response of the vibration test system is flat. The new approach to the problem limits with a new equalizer the energy in each of a number of narrow frequency bands covering the entire vibration test spectrum. The output signal of each frequency band can be controlled over a wide range, then recombined creating a shaped, equalized spectrum.

A primary advantage of the new equalization system is to allow continuous display of the average acceleration power spectral density over each frequency band during the random vibration test with a monitor containing a filter set identical to those of the equalizer system. Changes in the spectrum during test, which occur because of changes in ambient temperatures, mounting bolt tension, and the like, can be quickly identified and compensated at the equalizer.

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* Sponsored by the Professional Group on Instrumentation. To be published in Part 9 of the 1960 IRE INTERNATIONAL CONVENTION RECORD.

Books

Principles of Electronics, by M. R. Gavin and J. E. Houldin

Published (1959) by D. Van Nostrand Co., Inc., Princeton, N. J. 337 pages+6 index pages+1 bibliography page+5 appendix pages+xii pages. Illus. 5½×8¾. $5.75.

This book is an excellent middle ground fundamental text on electronics. Neither highly theoretical nor very practical, it is clearly intended as a student text serving well both major groups of electronics students, *i.e.*, those who wish to have merely a general ground in the field and those desiring a good basic course prior to advanced specialization.

While Laplace's and Poisson's equations are given along with a number of differential equations, a very excellent understanding of the text can be achieved with no mathematical training beyond calculus. In fact, the text is sufficiently nonmathematical so that a "practical" engineer or technician with mathematics through algebra and trigonometry can get 75 per cent or more of its value.

The use of British standard symbols may lead to some confusion on the part of American students and engineers and it seems very doubtful to this reviewer that the use of this text in American universities will be popular; however, this is a very minor drawback for an American electrical engineer who wishes to get a good fundamental knowledge of electronics which he missed in college.

From an American standpoint it seems that considerably more material on solid-state electronics, particularly the transistor, would have been justified. However, to do the subject full justice at this level would require a major increase in volume, presumably not desired by the authors.

All in all it is a very excellent volume.

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Fluctuation Phenomena in Semi-Conductors, by A. van der Ziel

Published (1959) by Academic Press, Inc., 111 Fifth Ave., N. Y. 3, N. Y. 164 pages+4 index pages +viii pages. Illus. 5¾×8¾. $6.50.

This book, as its title says, discusses noise in semiconductors. The book classifies noise into generation-recombination diffusion noise, and modulation noise, and proceeds to discuss examples of each kind.

The organization of the book, as far as the phenomenological discussion is concerned, proceeds from the simple to the difficult, with first a discussion of noise in semiconductor filaments, photoconductors, *p-n* junctions, and, finally, junction transistors, including a section on flicker noise.

In addition to the discussion of noise from a phenomenological viewpoint, there is a short discussion on each of the topics of noise measurements, circuit characterization of noise, general noise theorems, and circuit design for minimum noise.

The book is intended for students entering the field of noise study or workers in the field. Its chief virtue is the collection of a great deal of different but related material about noise in a single book, arranged by an experienced contributor to the field.

The book has a good, logical arrangement and includes accounts of the most recent advances in theories of noise. Perhaps the most serious obstacle to easy reading lies in the completeness of the coverage of existing theory. The book would have more general usefulness if Professor van der Ziel had selected what he feels is the theory which is most likely to endure the test of time and had spent more time expounding his choice of the most favored theory.

Dr. John L. Moll
Stanford Elec. Labs.
Stanford University
Stanford, Calif.

Handbook of Automation, Computation and Control, Vol. 2, E. M. Grabbe, S. Ramo and D. E. Wooldridge, Eds.

Published (1959) by John Wiley and Sons, Inc., 440 Fourth Ave., N. Y. 16, N. Y. 1033 pages+37 index pages+xxiii pages. Illus. 6⅛×9¼. $17.50.

This handbook volume, the second of a series of three covering the field of computers and automatic control, deals with the design and application of digital and analog computers. With the help of an impressive list of 40 authors, the editors compiled 31 chapters covering the full range of subjects, from programming to design, from installation problems to inventory control, and from differential analyzers to game-playing machines.

One mammoth chapter alone, occupying fully one quarter of the book, treats the subject of programming digital computers. It covers the whole gamut of subjects which concern the programmer and ends with an extensive bibliography. The next nine chapters deal with digital computers as a whole and their application to business, scientific, and other areas. There follow nine more chapters on the design of components, circuits, and the major sections of digital computers. Another eight chapters on all aspects of analog computers occupy one sixth of the pages of the volume. Three more chapters deal with miscellaneous topics, and there is one chapter on terminology. Coverage is restricted to U. S. equipment and techniques, with the exception of one Soviet computer and one Soviet algebraic language compiler.

To publish a handbook on any broad subject is a trémendous undertaking, and it is not made any easier when the subject matter is continually undergoing major technological changes. The editors have chosen the basic structure well, allocating space to each area in fair proportion. They have not been quite so successful in guiding individual authors. Some chapters are truly excellent summaries of their field. Some other chapters are fairly uninspired essays containing more editorial comment and less reporting of facts than one would like to see in this book. Some amble past all the landmarks in their fields without conveying much information.

A few of the authors may have misunderstood the nature of a handbook. If they looked in Webster's dictionary, his definition of a handbook as "a book of reference to be carried in the hand" may have seemed inadequate when the average two-handed person is confronted by three thick volumes. Instead, paraphrasing the preface of another well-known handbook (Kent's) from the same publisher, one might better define a handbook as a book containing selections from an accumulated mass of data, condensed, digested, and arranged in a handy form for publication. There was no mention of opinions.

Overlap is unavoidable when a field is divided among many authors. One would expect to find certain basic material summarized in more than one chapter, but in several instances none of the two or three scattered synopses contain the real meat. Equally disconcerting is an occasional tendency to describe the past or to anticipate the future, at the expense of the proven techniques in widespread use. Thus, there are pages of detailed programming examples from an early computer which, having served its purpose, was dismantled two years ago; in contrast, only a few lines of summary data dispense with the most common type of large business computers, more of which are still being installed every year. Again, three pages are devoted to a fair treatment of rather tentative techniques for character sensing, but the omnipresent keypunch is dismissed with a quarter page. Tedious as it may seem to the erudite author, the bulk of a handbook should be devoted to mundane matters, however "old-hat."

One might also wish that some authors had taken a broader point of view. The editors obviously designed the structure of the book to reflect both of today's major computer applications: business data processing and mathematical computation. Individual chapters, however, do not strike a proper balance. The lengthy programming chapter virtually ignores the former category, except perhaps for a section on sorting. Conversely, eight of the nine chapters describing equipment, installation planning, and applications by-pass the scientific and engineering field. Fortunately, much valuable material, to be found in this volume and its predecessor, is basic to both of these and to other fields.

The section on analog computers is possibly the best example in this volume of what one would expect in a handbook. This section is well edited (by W. J. Karplus), with a consistent point of view, a single set of symbols and terms, and a large proportion of figures and tables to summarize facts at a glance.

The type font used in the body is, for a handbook, surprisingly large and readable. It is unfortunately marred by poorly chosen bold-face type: minor headings overshadow major headings, obscuring the structure of the text. Reference would be simplified if section headings were repeated at the top of each page, as is the usual practice in handbooks.

It is to be hoped that the editors and publishers will have the opportunity to correct shortcomings in a future edition. Perhaps, by adopting smaller type, they could also add many more tables of up-to-date equipment characteristics, codes and conventions, user statistics, and the like, without increasing the price of the book. Broader coverage might be given to subjects such as electromechanical equipment and input-output programming.

The editors have indeed succeeded in creating an important reference work which summarizes far more subjects between two covers than are found in any other single publication on computers. This fact alone should secure a firm place for this volume next to the more specialized literature on the computer book shelf.

WERNER BUCHHOLZ
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Principles of Analog Computation, by G. W. Smith and R. C. Wood

Published (1959) by McGraw-Hill Book Co., Inc., 330 W 42 St., N. Y. 36, N. Y. 230 pages+4 index pages+viii pages. Illus. 6¼×9¼. $7.50.

This book appears to be written at a senior undergraduate or first-year graduate engineering level. At this level, it should be a useful text.

The presentation of the material of the book is from the point of view of those using operational amplifier analogue computers for the solution of various physical problems; only enough material concerning design principles of the component apparatus of such computers has been given to make it plausible that the components should operate as stated.

The authors discuss in some detail problem programming; the simulation of linear systems; the use of diodes, functional relays, and various types of function generators; and the use of implicit function techniques. Included is a very good collection of sets of problems to be solved.

This should be a useful text at the level for which it was written. In light of the purpose for which it appears to be intended, this reviewer regrets to note that very little discussion has been given to the problem of obtaining suitable scale factors, as this appears to be one of the major areas in which those just learning the use of analogue computers tend to have considerable difficulty.

Tables 3-1 and 3-2 of the text, indicating, respectively, the manner in which computer apparatus may be interconnected for the realization of various transfer functions, and the transfer functions of various passive networks, should be of considerable utility even to those with more experience in the field than the beginning student; and the discussion of five-impedance networks for use with a single amplifier together with the associated nomographs should also serve as a convenient reference.

There is, perhaps, a little too much detail regarding matters more relevant to servomechanism theory than to analogue computer use.

The discussion of implicit function generation is well-presented and complete enough to permit application of the principles given to more complex cases than those considered in the text.

This text should form a valuable addition to the literature on analogue computers, particularly for those whose interests center on servo-mechanisms theory, and who are just beginning their studies in the field.

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Analog Methods, 2nd edition, by Walter J. Karplus and Walter W. Soroka

Published (1959) by McGraw-Hill Book Co., Inc., 330 W 42 St., N. Y. 36, N. Y. 429 pages+7 index pages+44 appendix pages+xiii pages. Illus. 6¼×9¼. $12.50.

In recent years, stress on applications of digital computers has, to a certain extent, obscured the quiet and orderly parallel progress made on analog methods. One may easily lose sight of the possibility that cases exist where an analog computer may actually be superior to a digital one, and that there are other situations where the two methods may be advantageously used to complement each other. A book which gives an up-to-date description of the analog computer art is therefore a valuable addition to the library of anyone who needs computing aids. The present book fulfills this specification very well. The coverage is encyclopedic in nature. A complete description is given of almost every analog method which has ever been used, including both mechanical and electrical models with either lumped or distributed parameters. Copious references are furnished with each chapter. The development proceeds from the basic elementary operations of addition, subtraction, multiplication and division, through integration and differentiation, function generation, and solutions of algebraic and differential equations. Both ordinary and partial differential equations are treated, and for the latter, finite difference approximations are discussed as well as continuous models using stretched membranes, soap films, electrolytic tanks and conducting sheets.

The wide range necessitates some restriction in depth of penetration for individual topics. Matters such as stability and bandwidth limitations are treated in a rather rudimentary manner, making little use of the more sophisticated concepts of modern electric circuit theory. The tip-off in this respect is that there does not appear to be any mention of the names Nyquist and Bode. The discussion of organization of an analog computer program points out the advances that have been made in the use of problem boards to expedite rapid access to and relinquishment of the machine, as well as to preserve programs intact for subsequent use. After citing the advantages, the author comes up with this somewhat nullifying statement: "Even so, the programming of reasonably complex problems results in a veritable maze of plug-in wires, a factor which not infrequently leads to errors in programming and makes problem checking very difficult." If this is the case, it is not clear why such a condition should be allowed to persist. Surely, with widespread present day usage of such organizational aids as block diagrams and flow graphs, it should be possible to construct special purpose plug-in units for commonly used operational functions and thereby make the problem board layout readily identifiable with the graphical model.

The book appears to be well suited for textbook use at the upper undergraduate level. Illustrative problems and laboratory exercises are included.

W. R. BENNETT
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Murray Hill, N. J.

Principles of Optics, by M. Born and E. Wolf

Published (1959) by Pergamon Press, 122 E. 55 St., N. Y. 22, N. Y. 715 pages+28 index pages+58 appendix pages+xxvi pages. Illus. 6½×10. $17.50.

This book, although based in part on Born's *Optik*, must be considered a new book as it contains less than 50 per cent of the old material and 75 per cent of its contents are different from *Optik*. In fact, half of this book is basic electromagnetic theory and must be read and reviewed in that context. The first two chapters describe the properties of the electromagnetic field and the treatment is similar to the standard references. The third chapter describes the foundation of geometric optics. Chapter IV describes optical imaging and works into the geometric theory of aberrations (Chapter V), and into the basic principles of image forming instruments (Chapter VI), contributed by P. A. Wayman. Chapter VII describes the principles involved in the theory of interference and interferometers and was contributed by W. L. Wilcock. Chapter VIII introduces the diffraction theory which is used in Chapter IX to derive the theory of aberrations from the diffraction theory viewpoint. This is followed by a particularly excellent chapter describing the theory and application of partial coherence (Chapter X). Chapter XI is a shortened treatment of exact solutions in diffraction theory contributed by P. C. Clemmow. Chapter XII, written by A. B. Bhatia, describes the diffraction of light by ultrasonic waves. Chapter XIII is based on the optics of metals and is followed by an excellent treatment in Chapter XIV of the optics of crystals. These last two chapters are revised versions of part of *Optik*. The revision and extension of these chapters was performed by A. M. Taylor and A. R. Stokes. The appendixes are excellent contributions in themselves. The first is on the calculus of variations and is based on D. Hilbert's unpublished notes. The second is on the analogy of light optics, electron optics and wave mechanics by D. Gabor. The third is by P. C. Clemmow on the asymptotic approximations to integrals. The fourth is on the Dirac delta function. The last five also elucidate further on mathematics in the text.

This book is excellently written, especially when one considers the variety of subjects and authors. It has been needed for many years. The major complaint must also be that it has been written over many years and thus, although some sections contain very new material, other sections end with the material as it existed five years ago.

The book will materially aid those workers who desire an over-all look into the mathmatical theory of optics. It can serve as a textbook for several courses and a reference book for others. It is recommended as an outstanding addition to the electromagnetic theory literature.

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RECENT BOOKS

Bershader, Daniel, *The Magnetodynamics of Conducting Fluids.* Stanford University Press, Stanford, Calif. $4.50. A review of the field of behavior of conducting fluids in magnetic fields.

Besserer, C. W. and Hazel, *Guide to the Space Age.* Prentice-Hall, Inc., Englewood Cliffs, N. J. $7.95. Presents in clear and simple language the terminology of space technology and guided missilery.

Contini, Renato and Paul T. Bryant, Eds., *Engineering College Research Review 1959.* Engineering College Research Council of the American Society for Engineering Education, Urbana, Ill. $2.00. A list of all research projects and research personnel at institutions holding membership in the Engineering College Research Council.

Jastrzekski, Zbigniew D., *Nature and Properties of Engineering Materials.* John Wiley and Sons, Inc., 440 Fourth Ave., N. Y. 16, N. Y. $11.00. Provides the reader with the basic knowledge necessary for intelligent selection and use of materials for special engineering applications and prepares him to solve materials problems of the future.

Lettenmeyer, Lore, *Dictionary of Atomic Terminology.* Philosophical Library, Inc., 15 E. 40 St., N. Y. 16, N. Y. $6.00. Provides a selection of the essential scientific and technical terms employed in connection with atomic and nuclear physics, reactor engineering, radiation physics and associated fields, with the objective of facilitating the study of the relevant foreign literature on the subject.

Leinwoll, Stanley, *Shortwave Propagation.* John F. Rider Publisher, Inc., 116 W. 14 St., N. Y. 11, N. Y. $3.90. Presents the basic principles of shortwave radio propagation, and how it is used in long distance radio communication.

Nayler, J. L., *Dictionary of Aeronautical Engineering.* Philosophical Library, Inc., 15 E. 40 St., N. Y. 16, N. Y. $10.00. An illustrated dictionary which provides concise definitions of aeronautical engineering terms.

Proceedings of an International Symposium on the Theory of Switching (Parts I and II). Harvard University Press, Cambridge, Mass. $15.00. Consists of 39 papers which were presented at the symposium, which was held at the Computation Laboratory of Harvard University, April 2–5, 1957.

Proceedings of the Fourth Midwest Symposium on Circuit Theory. $7.00. Purchase from: Raymond Kipp, Marquette University, 1515 W. Wisconsin Ave., Milwaukee 3, Wis.

Schure, A., *R-F Amplifiers.* John F. Rider Publisher, Inc., 116 W. 14 St., N. Y. 11, N. Y. $2.40. Presents a discussion of amplifiers—low powered as well as high powered—used in the RF portion of the radio frequency spectrum. Special emphasis is placed on the properties of resonant circuits as applied to power amplifiers.

Smith, Woodrow, *Radiotelephone License Manual,* 2nd ed. Editors and Engineers, Ltd., Summerland, Calif. $5.00. This question and answer manual is intended to be used as an aid in preparing for examinations for the various grades of radiotelephone license or permit.

Van Valkenburgh, Nooger and Neville, Inc., *Basic Electronics—Vol. 6.* John F. Rider Publisher, Inc., 116 W. 14 St., N. Y. 11, N. Y. $2.90 (paperbound) $3.60 (cloth binding). Companion volume to the present five-volume course on basic electronics; intended to enable individuals, schools, and industrial programs to expand into areas of semiconductors, transistors and frequency modulation.

Scanning the Transactions

Dilocycles and trilliseconds? An IRE Technical Committee once jokingly defined a kilocycle as a two-wheeled vehicle for transporting ten centipedes. While there can be no doubt in the mind of any electronics engineer as to the real meaning of kilocycle, the same certainly cannot be said of other units of measure which are in use today. Does everyone remember that picofarad means 10^{-12} farad? Do you recognize nanosecond (10^{-9} second) or gigacycle (10^9 cycle)? The problem of finding suitable numeric prefixes for very large and very small quantities is becoming increasingly vexing because the flow of technical developments is carrying us to new orders of magnitude which have not yet been adequately staked out in our language. We do not even have agreement on such common terms as billion, trillion and quadrillion. To the British they mean the second, third and fourth powers of a million (a much more logical system than the American system). Thus the British billion is the equivalent of the American trillion. We need a system that will give us numeric prefixes which are short, recognizable and logical over a broad range of values. If we examine what we have now in the range 10^{-6} to 10^6 we find that Greek prefixes are used for multiples greater than one and Latin is used for submultiples, except micro. This leads very logically to the suggestion that we always use Greek for positive powers of ten and Latin for negative powers. The result is the interesting system shown below. (A. P. G. Peterson, "The Greeks had a word for it," IRE TRANS. ON ENGINEERING WRITING AND SPEECH, December, 1959.)

Value	Prefix	Symbol	Value	Prefix	Symbol
10^3	kilo	K	10^{-3}	milli-	m
10^6	dilo	D	10^{-6}	billi-	b
10^9	trilo	TR	10^{-9}	trilli-	t
10^{12}	tetrilo	TT	10^{-12}	quadrilli-	qd
10^{15}	pentilo	PN	10^{-15}	quintilli-	qn
10^{18}	hextilo	HX	10^{-18}	sextilli-	sx
10^{21}	heptilo	HP	10^{-21}	septilli-	sp
10^{24}	oktilo	OK	10^{-24}	octilli-	oc
10^{27}	enneilo	EN	10^{-27}	nonilli	nn
10^{30}	dekilo	DK	10^{-30}	decilli	dc

Radar astronomy, although intimately associated with radio astronomy, is rapidly assuming a role of sufficient importance to justify the distinction of a name of its own. It has its beginnings as far back as 1925 when the Carnegie Institution of Washington and the Naval Research Laboratory began probing the ionosphere by means of pulsed radio signals. Radar astronomy made its first leap beyond the earth's environs in 1946 when the Army Signal Corps contacted the moon. Another major breakthrough came in 1957 when M.I.T. Lincoln Laboratory reached Venus by radar. Only last month Stanford announced that it had contacted the Sun. These experiments have given us new information on interplanetary distances. Future radar soundings of Venus and certain asteroids will give us a very accurate check on the size of our solar system. However, the return signal of a radar can provide us with a good deal more information than simply distance. By carefully analyzing the return pulse, deductions can be made concerning such matters as the density and kinetic temperature of ionized gases, motions of electrons, the magnitude and direction of any magnetic field present, and the nature and composition of the surfaces of solid bodies. This gives us the wherewithal to learn much more about the sun, the moon, the planets and the space between. For example, we should in time be able to determine the height of mountains on the moon, the rotational period of Venus (which is obscured to us by clouds), and the velocity and course of the highly important streams of charged particles known to be flowing from the sun toward the earth. Recent progress in large antennas, powerful transmitters, very low noise receivers, and special signal processing techniques all point to an increasingly important role for radar in future space research. (K. J. Craig, *et al.*, "The role of radar in space research," IRE TRANS. ON MILITARY ELECTRONICS, January, 1960).

The measurement of blood flow is one of the most fundamental of physiological measurements. Investigators have worked for more than three centuries to develop methods for measuring various parameters of the circulation of the blood. Despite this, there is no generally accepted method today for measuring volume of flow. Rather, a number of methods are available, all of limited applicability. In some instances various types of ingenious velocity or pressure sensing devices (in one case, a tiny blood-driven turbogenerator) are inserted directly into the blood vessel. Recent developments in the electronic art, however, have focused considerable attention on indirect methods which do not require opening the circulatory system. One technique involves producing and then detecting nuclear magnetic resonance of hydrogen protons in the blood. There is also much interest in flowmeters of the electromagnetic type. Here the blood, because it is an electrical conducting fluid, acts as a moving conductor which, in the presence of an electromagnetic field, will induce an EMF proportional to the velocity of flow. This same principle, incidentally, was used as far back as 1832 by Faraday to measure tidal changes in the Thames River. Another very promising method makes use of the fact that ultrasonic waves travel faster downstream than upstream by an amount related to the velocity of the blood. These and other techniques were the subject of an important conference held last June under the joint sponsorship of the University of Nebraska School of Medicine and the IRE Professional Group on Medical Electronics. The 26 pages presented at the conference have now been published by the PGME. Since the work of virtually all the leading investigators in this field is reported, the issue stands as an especially valuable reference to the bio-medical electronics community. (Blood Flowmeters Symposium Issue, IRE TRANS. ON MEDICAL ELECTRONICS, December, 1959.)

A new electron gun for TV picture tubes offers the possibility of the first major change in gun structure for television displays in many years. The gun has several unique design features, one of them being that the beam emanating from the cathode is unmodulated. Modulation is accomplished by lateral deflection of the beam, causing it to be partially intercepted in a controlled manner as it passes through an aperture. The most important difference between this and standard guns, however, is that it will operate with a much lower video signal—about 7 volts—and thus is eminently suited for use in transistorized sets. (K. Schlesinger, "A new electron gun for picture displays with low drive signals," IRE TRANS. ON ELECTRON DEVICES, October, 1959.)

Klystron amplifiers have now joined the low-noise club. Many people have considered klystrons to be inherently noisy. Others have believed otherwise, theorizing that noise limitations were basically no different for klystrons than for conventional traveling-wave and backward-wave tubes. However, there was no experimental proof of the theory. Meanwhile, klystrons continued to be noisy. The theorists, who maintained that the noise figure is determined mostly by the gun and not by the microwave circuit, have now been vindicated. The principles of low-noise guns, developed earlier for wave tubes, have been applied successfully to klystron amplifiers to produce tubes with noise figures as low as 6.7 db. This experimental verification opens the door to the use of tuned radio-frequency receivers for radar or radio astronomy, having the combination of high sensitivity, high gain, and wide dynamic range. (R. G. Brockwell, "Low-noise klystron amplifiers," IRE TRANS. ON ELECTRON DEVICES, October, 1959.)

Abstracts of IRE Transactions

The following issues of TRANSACTIONS have recently been published, and are now available from the Institute of Radio Engineers, Inc., 1 East 79th Street, New York 21, N. Y. at the following prices. The contents of each issue and, where available, abstracts of technical papers are given below.

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Circuit Theory

VOL. CT-6, NO. 4, DECEMBER, 1959

Analysis of Periodic Filters with Stationary Random Inputs—Harry Urkowitz (p. 330)

A periodic filter is one whose frequency characteristic is periodic in frequency. Examples are delay-line cancellers for moving-target indication and delay-line sweep integrators. Z-transform techniques have proved useful in the analysis and synthesis of these filters when determinate inputs are involved. The determination of the mean square output and other statistical properties with random inputs has heretofore usually involved numerical integration, even for fairly simple cases. This paper presents formulas for computing the mean square value and other statistical properties of the output when the input is a stationary random function. The formulas involve the values of the input autocorrelation function at integral multiples of the basic delay and the sums of product pairs of the coefficients in the Z-transform power series. Simple algebraic forms result, making slide-rule computation feasible. The effects of internal noise are also considered by means of the same techniques. Specific formulas are derived for single and double cancellers, velocity-shaped cancellers, and sweep integrators.

Generation of Squares with the Use of Nonlinear Resistors—E. Grosswald (p. 334)

Whenever great accuracy is not required, a convenient way to obtain squares, and hence, to multiply, in analog computers is by the use of nonlinear resistors, especially thyrite rods, in certain circuits.

These circuits are usually determined, more or less empirically, by starting from schemes that have given good results in the past and modifying them, or by varying the numerical values of the resistors used, until "best" results are obtained. In the present paper the concept of "best" results is clarified. Furthermore, it is shown that, regardless of the complexity of the circuit, the input-output characteristic depends only on two parameters. An explicit method is given by which the numerical values of the resistors used in the thyrite circuit can be computed for the given characteristics of the thyrite rod used in order to achieve desired "best" results.

Direct Single Frequency Synthesis from a Prescribed Scattering Matrix—D. C. Youla (p. 340)

This paper presents two techniques for synthesizing an n-port (at a single frequency) directly from its normalized scattering matrix without recourse to its associated impedance matrix. Both methods depend on standard matrix canonic forms. In the first one, all the loss is extracted immediately in the form of n resistors and the problem is reduced to the synthesis of a lossless $2n$-port. The second makes use of the Jordan decomposition of a matrix and leads to a hybrid mixture of ideal transformers, reactances, gyrators and resistors. The only elements required for a complete synthesis are ideal transformers, lossless capacitors, inductors, and gyrators, and positive and negative resistors. It is shown that synthesis from a prescribed scattering matrix requires, in general, irrational operations (computation of eigenvectors, eigenvalues, etc.) whereas synthesis from a prescribed impedance matrix (if it exists) can be achieved with rational operations alone.

Minimal Realizations of the Biquadratic Minimum Function—Sundaram Seshu (p. 345)

The purpose of this paper is to obtain rigorously minimal realizations of the biquadratic minimum positive real function without the use of transformers. For this purpose a few theorems are proved about the structure of the network realizing a minimum pr function. This is followed by an exhaustive search of networks in increasing order of number of elements. It is proved that the modified Bott-Duffin (or the Reza-Pantell-Fialkow-Gerst) realization using seven elements is rigorously minimal in number of elements, except for the special cases $Z(0)=4Z(\infty)$ and $Z(\infty)=4Z(0)$. These two special cases have five element realizations.

On the Representation of Transients by Series of Orthogonal Functions—H. L. Armstrong (p. 351)

When problems having to do with transients are solved by the Laplace transform or equivalent methods, one may be left with the necessity of solving a rather complicated equation in the transform variable. This may be avoided, in many cases, by getting the solution in the form of a series. Laguerre functions have had some use for that purpose. It is shown here how another set of functions, which are just the Jacobi polynomials whose argument is an exponential, may be used instead. The use of this latter set permits a rather elegant means of evaluating the coefficients in the expansion to be used. In an appendix, ways of applying the mathematical techniques used are investigated. These involve the complex "Faltung" theorem, for investigating questions of orthogonality and orthonormality in general.

Improving the Approximation to a Prescribed Time Response—John D. Brule (p. 355)

The topic considered in this paper is the problem of obtaining the Laplace transform of a prescribed impulse response, under the constraint that this transform must be a realizable rational function. In general, the solution of this problem requires that approximations be made, either in the time domain or in the frequency domain. A procedure is developed which provides a systematic method for improving the approximation by making small changes in the poles and residues of the transfer function. The effects of such changes on the impulse response are evaluated by means of a Taylor series expansion of the impulse response. It is shown that only the first two terms of this expansion provide a reasonably accurate estimate of these effects. A set of normalized curves are prepared which allow the designer to determine how a given pole or residue should be changed in order to improve the approximation in the time domain. The procedure is demonstrated by applying it to a numerical example.

An Extension of Wiener Filter Theory to Partly Sampled Systems—H. M. Robbins (p. 362)

The growing use of digital computers as components of control systems has given great importance to the study of linear systems which are partly sampled and partly continuous. This paper treats the problem of optimizing the simplest possible mixed system consisting of an input filter with transfer function $K(s)$, a sampler with sampling interval T, and an output filter with transfer function $L(s)$. Given the power spectra of the input signal and the noise, the object is to find a realizable K and L which in combination minimize the mean square difference between the output h and a "desired output" h_d. h_d is defined by a "desired transfer function" $G_d(s)$, not necessarily realizable, which would produce h_d from the input signal if the noise were absent.

KL will in general contain factors periodic in s with period $2\pi j/T$, and such factors may be moved to either side of the sampler without changing the final output, thus introducing a considerable arbitrariness in K and L. However, since these periodic factors represent linear operations on discrete data (such as might be performed inside a digital computer), it is appropriate to separate them out. There are then three functions to be determined: the nonperiodic part of K, the nonperiodic part of L, and the remaining (periodic) factor of KL. Methods for determining these three functions are given. The interesting theoretical point is that the determination is not always unique. In general, there will be a finite number of distinct but equivalent solutions.

Network Functions with a Constant Imaginary Part—H. J. Orchard (p. 370)

The paper considers the problem, suggested by the circuitry of the so-called seven-league oscillator, of constructing a positive-real rational function whose imaginary part makes an equal-ripple approximation to a constant value over a wide band of frequencies. It gives an exact solution using elliptic functions and shows that the resulting function satisfies the conditions for realization with either an RL or an RC circuit. Performance curves and computing details are included.

Generalizations of the Concept of the Positive Real Function—A. H. Zemanian (p. 374)

Two generalizations of the concept of the positive real function are made that are applicable to transfer functions whose poles outnumber their zeros by any amount. Some previously published results are briefly discussed. Then, the second generalization is developed still further. In particular, the properties of the zeros on the imaginary axis are established and are found to be analogous to the corresponding properties for positive real functions. In addition, several new tests for the generalized functions are developed, one of which serves as a new test for positive real functions wherein the Sturm sequence is replaced by a more easily calculated sequence. Reza's "double alternation" property for positive real functions is extended to the generalized functions. Finally, a property of the phase functions of the positive real functions is extended and the use of some common transformations is discussed which, in turn, leads to still another type of generalization.

Reviews of Current Literature (p. 383)

Correspondence (p. 386)

The 1960 Solid-States Circuits Conference (p. 399)

Annual Index 1959 (follows p. 402)

Electron Devices

Vol. ED-6, No. 4, October, 1959

Large Signal Bunching of Electron Beams by Standing-Wave and Traveling-Wave Systems—S. E. Webber (p. 365)

Large signal bunching processes in the presence of space charge are studied by extending techniques used to compute multi-cavity klystron bunching. Bunching capability of traveling-wave and standing-wave systems is examined by using an assumed spatial and time distribution of electric field, and interesting high degrees of bunching are predicted.

A Theoretical Study of Ion Plasma Oscillations—W. W. Peterson and H. Puthoff (p. 373)

A theoretical study is made of oscillations in an ion plasma, which is in an electron beam. The effect of ion motion on the electrons is neglected, and the ions and the electrons are assumed to have constant and equal density in the equilibrium position. Symmetric and transverse oscillations are studied, both in planar and cylindrical geometry. For planar geometry, the frequency of oscillations for both symmetric and transverse modes is independent of amplitude, while the frequency increases with amplitude for cylindrical symmetric oscillations. For both cylindrical and planar geometry, the presence of the anode boundaries reduces the frequency for transverse ion oscillations, but does not affect the frequency for symmetric-type oscillations.

A New Electronic Gun for Picture Display with Low Drive Signals—Kurt Schlesinger (p. 377)

The paper describes an approach to the problem of picture tube guns for small signal service.

A Pierce-type cathode delivers a collimated parallel beam of 1600 microamperes at 250 volts (microperveance: 0.4). This beam is injected into a cylindrical cavity of appreciable length ($\frac{3}{4}$-inch long, $\frac{1}{4}$-inch diameter). It is focused upon a small aperture at the far end using a parabolic axis potential. This axial focusing field is approximated by three cylinder segments at two intermediate voltages.

To modulate the beam by lateral deflection, the cavity is again bisected through an axial plane and signal voltage is set up between half cylinders. This modulation by two crossed-electrostatic fields ("CFM" modulation) has been successfully applied in transistorized television, using a seven-volt video signal on a beam of 900 microamperes.

Diffused Silicon Nonlinear Capacitors—A. E. Bakanowski, *et al.* (p. 384)

Diffused silicon nonlinear capacitors have been fabricated by solid-state diffusion. The resulting graded p-n junction is a planar structure which permits low series resistance R_s relative to the minimum capacitance $C_{\min}$, which is measured at a reverse voltage slightly less than the breakdown voltage. A cutoff frequency $f_c=(2\pi R_s C_{\min})^{-1}$ is used as a figure of merit; values up to 150 kmc have been obtained.

These "varactor" diodes may be used as UHF and microwave amplifiers and as harmonic generators. The noise figures of the UHF amplifiers are better than the best noise figures obtainable by present electron-tube techniques. These diodes are also efficient harmonic generators.

The Design and Performance of Grid-Controlled, High-Perveance Electron Guns—H. E. Gallagher (p. 390)

The focusing electrode and a probe projecting through the cathode serve as control electrodes for the current from a convergent-beam electron gun. The principal advantage of this type of "grid" is that there is no interception of the high-current-density beam by the probe-grid. This paper presents the design procedure and experimental results for typical probe-gridded guns. The design procedure is used to obtain the desired perveance, beam diameter, and approximate laminar electron flow. The probe geometry that results in a minimum beam distortion is discussed. The range of values of amplification factor obtainable and the influence of probe geometry on this factor are discussed. The magnetic field required for focusing the beam from a probe-gridded gun is compared with that required for perfect laminar flow and for focusing the beam from a nongridded gun of similar design. An electrolytic tank in conjunction with an analog computer was used to plot electron trajectories, with the effect of space charge included, for the probe-gridded gun and a similar nongridded gun. A comparison of the electron optics of the gridded and nongridded gun is made. Electrical breakdown and beam current during the interpulse time are problems considered. Methods used to minimize electrical breakdown and interpulse beam current are presented. Several models of probe-gridded guns were constructed. The measured characteristics of these guns demonstrate that the advantages of grid control can be obtained with only a minor effect on gun perveance and beam focusing.

The Effects of Initial Electron Velocities and Space Charge in Secondary Emission—M. D. Hare (p. 397)

This paper treats a secondary emitter as a fixed-temperature thermionic emitter with an equivalent work function which depends for its value upon the current density of the incident primary electrons. This permits Langmuir's treatment of the parallel-plane thermionic diode to be applied to secondary emission. The resulting equations account quantitatively for observed secondary-emission effects caused by space charge and initial electron velocities. The paper concludes with a discussion of three specific electron devices in which secondary-emission effects due to space-charge and initial electron velocity are important.

Space-Charge Layer Width in Diffused Junctions—R. M. Scarlett (p. 405)

This paper outlines a calculation of space-charge layer width in a planar junction made by diffusing an n or p impurity (assumed to follow a Gaussian or a complementary error function distribution) into a uniformly doped crystal of opposite conductivity type. The collector junction of most drift transistors conforms closely to this model. An exponential approximation to the impurity distribution permits curves to be drawn of the space-charge layer penetration in each direction from the junction as a function of applied reverse voltage, and of the electric field distribution. The quantities involved are normalized in terms of the initial doping level N_1, the impurity diffusion length $L=2\sqrt{Dt}$, and the junction depth x_j. The curves should be useful in calculating depletion-layer capacitance, transistor punch-through voltage and junction breakdown voltage.

Electron Beam Characteristics in Radially Varying Periodic Magnetic Fields—C. C. Johnson (p. 409)

Periodic magnetic fields are being widely used for the light-weight focusing of beams in high-power traveling-wave tubes. In many tube designs, there exists a considerable amount of radial variation in the magnetic focusing field. The effect of this radial field variation is investigated analytically as an extension of the previous work in this field. The usual design curves of α vs β are plotted with three variable parameters: ripple, cathode shielding parameter K, and radial field variation parameter x_0. It is noted that it is important to keep the magnetic-field strength constant at the beam edge over a considerable variation of the magnetic-field parameter x_0.

The Effect of Secondary and Backscattered Electrons in the Parallel-Plane Diode—L. A. Harris (p. 413)

Separate calculations are carried out to determine the influence of true, low-energy secondary electrons and of higher-energy backscattered electrons released from the anode of the parallel-plane, space-charge limited diode. Both groups depress the potential, increase the field near the anode, and decrease the net diode current by small but appreciable amounts.

Theory of the Amplitron—G. E. Dombrowski (p. 419)

The Amplitron device is analyzed from a normal mode viewpoint based on predominance of the reentrant character of the stream; the analysis is therefore valid for devices with short electron recirculation times and moderate signal levels. The nature of the space charge deduced from the above hypothesis is that of a rotating set of identical spokes having equal angular spacing in the interaction space.

The induction effects of this space charge configuration upon the delay line are calculated, accounting for the periodic nature and the short length of the delay line. It is found that both forward and backward-traveling waves are appreciable and must be considered.

The fields in the interaction space are resolved into Fourier component traveling waves. The amplitude of the synchronously interacting wave is related to 1) the input signal, 2) the forward-traveling wave resulting from space charge induction, and 3) the backward-traveling wave resulting from space charge induction. Use is made of the phase relation (adiabatic theory) between the space charge and the synchronously traveling wave to obtain a consistent solution determining the phase relation between the input wave and the space charge.

The above relationship between the space charge and the input signal allows the calculation of complex (vector) gain of the Amplitron. It is thus shown that the Amplitron is a nonlinear, or saturated, amplifier. A limit to the gain is observed; the backward-traveling wave is essential in determining it. Phase-dependence on operating RF level, or RF phase pushing, is noted; this type of phase variation does not exceed 90°. Calculations as a function of frequency show the bandwidth to be expected. It is found that conditions may lead to oscillation; feedback mechanisms reside in the backward-traveling wave and in the stream reentrance. The degree of input mismatch of the operating tube is discussed.

Low-Noise Klystron Amplifiers—R. G. Rockwell (p. 428)

The principles of low-noise guns have been applied to klystron amplifiers with good corroboration of the theory. In the past, many people thought that klystrons had inherently high noise figures, while others advanced the theory that low-noise guns might be used with klystrons as well as with wave tubes. The development to be described here shows that the former impression is not true and verifies that low-noise klystron amplifiers are possible.

The most obvious difference between the guns for low-noise klystron amplifiers and those typical of low-noise traveling-wave tubes is the higher beam current which is required for adequate klystron gain. A byproduct of this higher current is a wide dynamic range.

In addition to the development of the electrical parameters, a major effort went into klystron construction techniques somewhat peculiar to low-noise klystron amplifiers. The data taken show that alignment of the low-noise gun electrodes with the drift tube, alignment of the beam with the magnetic field, elimination of the collector's secondary electrons from the beam, and cleanliness of the tube are of primary importance in constructing a low-noise klystron amplifier.

Several two-cavity, low-noise klystron amplifiers were built for operation in both S-band and C-band. The typical low-level gain was 11.5 db, and the saturated power output was 180 mw. Several tubes exhibited noise figures below 9 db; the lowest value obtained was 6.7 db.

The Effect of Beam Cross-Sectional Velocity Variation on Backward-Wave-Oscillator Starting Current—N. C. Chang, *et al.* (p. 437)

Low-voltage helix-type backward-wave oscillators require a starting current that rises to infinity toward the low-frequency end of the tuning range. The effect has been attributed to the raising of the space-charge parameter QC by the dc space-charge-induced velocity spread. H. R. Johnson has calculated the velocity-spread effect on starting current qualitatively, but the predicted non-oscillation frequency is generally much lower than the observed one. As a further analysis, space-charge wave propagation in an electron beam having an actual cross-sectional variation of dc velocity is investigated. It is shown that the RF current modulation in the slow space-charge wave is concentrated in the region of the slowest-moving electrons. In a helix-type backward-wave oscillator using a hollow beam, the slower electrons are farther away from the RF circuit, so that the effective impedance for the slow space-charge wave may be considerably reduced. The use of an impedance reduction factor therefore provides better agreement between theory and experiment with regard to the starting-current phenomenon. Theoretical and experiment results of the investigation are presented.

The Cylindrical Field Effect Transistor—H. A. R. Wegener (p. 442)

The characteristics of a cylindrical field-effect transistor are derived analytically on the basis of Shockley's theory of the planar field-effect transistor. It is found that the cylindrical device is capable of giving twice the (voltage) amplification factor of that of the planar device. Its frequency behavior should be comparable to that of the Shockley unit. Because of the loss of one degree of freedom, the transconductance and power characteristics of the cylindrical field-effect transistor are sharply limited. Experimental data support the analytical results.

Small-Signal Theory of Multicavity Klystrons—G. R. White (p. 449)

A small-signal formulation is developed which is valid for multicavity klystrons with nonideal gaps. The complete one-dimensional description of modulation at the gap is given, including the modifications due to space-charge forces. Stagger-tuned amplifiers are treated by matrix and by scalar methods. Equations useful for electronic computation of response are presented. The necessity for the formulation, and its validity, are discussed.

Cross Modulation and Nonlinear Distortion in RF Transistor Amplifiers—M. Akgun and M. J. O. Strutt (p. 457)

In order to avoid untractable calculations, the transistor four-pole is assumed to be short-circuited for ac at its output. Furthermore, the internal impedance of the signal source is assumed to be zero. First the nonlinear distortion effects in a grounded base intrinsic transistor are calculated. Then, the formulas are reverted to a grounded emitter intrinsic transistor, taking into account the extrinsic base lead resistance. They are confirmed by measurements of third harmonic distortion and of cross modulation. The measured curves of cross modulation vs collector bias current show a sharp minimum. This unexpected effect is explained by an extension of the theory, which takes into account previously neglected terms. The explanation is successfully tested by experiments. Comparisons with cross modulation in amplifier tubes are made.

Experimental Notes and Techniques (p. 468)

Contributors (p. 470)

Annual Index, 1959 (Follows p. 472)

Engineering Writing and Speech

Vol. EWS-2, No. 3, December, 1959

Editorial (p. 65)

Talking and Writing About Science—Sir Lawrence Bragg (p. 68)

Many of the pitfalls inherent in talking and writing about science can be avoided if one but heeds the admonitions presented here.

The Greeks Had a Word for It—Arnold P. G. Peterson (p. 72)

Numerical mileposts have changed down through the ages, always in the hope of providing a more universally understood and acceptable system. Here is another step in this direction.

Turning Engineers into Authors—Walter A. Murphy (p. 74)

Many companies have developed, or are in the process of developing, programs that seek to help engineers and scientists write up their work for publication. This article shows one approach to this problem.

Keys to Good Article Writing—John M. Carroll (p. 77)

Frequent and effective publication in engineering magazines have helped many engineers to fame and fortune. Here are a few suggestions to increase the chances of acceptance and the readership of your article.

A Review of the IRE-PGEWS—T. T. Patterson (p. 82)

How does PGEWS stand after two-and-one-half years of operation? What future course should be taken? The present National Chairman expresses his views.

Some Legal Considerations in Presenting Technical Information—Robert H. Rines (p. 83)

Everyone who has ever written or presented a paper, or plans to do so, should have some idea of the legal problems involved. Here is some must reading!

Information Gaps and Traps in Engineering Papers—Herbert B. Michaelson (p. 88)

Information faults in manuscripts for professional journals are caused by two kinds of structural defects: the information gap, in which essential information is omitted, and the information trap, in which important points are not emphasized and are obscured in the paper.

Book Review—J. D. Chapline (p. 92)

Contributors (p. 93)

Medical Electronics

Vol. ME-6, No. 4, December, 1959

Introduction—Lee B. Lusted (p. 193)

Foreword—F. L. Dunn and H. G. Beenken (p. 194)

An Ultrasonic Flowmeter—J. F. Herrick and J. A. Anderson (p. 195)

Design Considerations for Ultrasonic Flowmeters—William R. Farrell (p. 198)

Resumé of Discussion Group on Ultrasonic Flowmeters—J. F. Herrick (p. 202)

A Pulsed Ultrasonic Flowmeter—D. L. Franklin, *et al.* (p. 204)

A pulsed ultrasonic flowmeter has been developed specifically for the simultaneous measurement of blood flow through various major blood vessels in the intact unanesthetized animal. The flow section is a small (–3 cm) lucite cylinder which is clamped about the blood vessel. Piezoelectric crystals are mounted on the flow section so that bursts of 3-mc sound may be transmitted alternately upstream and downstream. The flowmeter develops a voltage which is proportional to the difference in the upstream and downstream transit times of the sound. This voltage is recorded continuously and calibrated in terms of flow. Under optimal conditions, the output voltage is a linear and accurate representation of volume flow within ±5 per cent, independent of the velocity profile. The flowmeter responds to a step variation in flow within 0.01 second. The maximum noise and baseline drift is equivalent to a flow velocity variation of less than 1 cm/second measured over a 4-hour period.

Comparative Pulsatile Blood Flow Contours Demonstrating the Importance of RC Output Circuit Design in Electromagnetic Blood Flowmeters—T. Cooper and A. W. Richardson (p. 207)

Measurement of Cardiac Output in Unrestrained Dogs by an Implanted Electromagnetic Meter—Frederick Olmsted (p. 210)

Gated Sine-Wave Electromagnetic Flowmeter—A. Westersten, *et al.* (p. 213)

Chopper-Operated Electromagnetic Flowmeter—Francis L. Abel (p. 216)

The problem of design of a square-wave electromagnetic flowmeter may be simplified by the use of a mechanical chopper as the gating device. Such an instrument has been assembled using commercial components costing less than $1000. A commercial 400-cycle chopper amplifier, Offner model 190, was modified to perform the sampling. Carrier signal was provided by Tektronix 162 and 161 generators. Proper synchronization with the chopper is obtained by use of the 161 delay control. Magnet assemblies were made of ferrite toroidal cores and platinum electrodes, cast in epoxy resin and powered directly by a Heathkit 70-watt amplifier.

Using a carrier frequency of 400 cps, good frequency response, stability, and signal-to-noise levels were attained. Calibration curves are linear for forward and backward flow. Sensitivity was sufficient to record blood flow levels of 1 ml per minute.

The Square-Wave Electromagnetic Flowmeter: Theory of Operation and Design of Magnetic Probes for Clinical and Experimental Application—M. P. Spencer and A. B. Denison, Jr. (p. 220)

Electromagnetic Blood Flow Measurements in Extracorporeal Circuits—A. R. Cordell and M. P. Spencer (p. 228)

A Magnetic Flowmeter for Recording Cardiac Output—H. W. Shirer, *et al.* (p. 232)

An Integrating Drop-Flowmeter for Optical or Pen Recording—C. N. Peiss and R. D. McCook (p. 234)

Performance and Application of a Commercial Blood Flowmeter—W. Thornton and B. Bejack (p. 237)

Design goals and reasons for the selection of a 60-cps square-wave electromagnetic blood flowmeter are presented. Detailed description of the flowmeter is given with emphasis on demodulator techniques. Complete performance data of step function response, stability, and performance with small and large flows are shown graphically. One application of the flowmeter and analog integrator is given showing response to a periodic hydraulic flow.

The DC Electromagnetic Flowmeter and Its Application to Blood Flow Measurement in Unopened Vessels—W. Feder and E. B. Bay (p. 240)

Flowmeter for Extracorporeal Circulation—G. Albertal, *et al.* (p. 246)

Discussion of Orifice-Plate Flowmeter for Extracorporeal Circuit—F. Robicsek (p. 249)

Resumé of DC Electromagnetic Flowmeter Group Discussion—W. Feder (p. 250)

Certain Aspects of Hydrodynamics as Applied to the Living Cardiovascular System—Donald L. Fry (p. 252)

The Measurement of Pulsatile Blood Flow by the Computed Pressure Gradient Technique—Donald L. Fry (p. 259)

Methods of Flow Estimation by Pressure Sensing Techniques—Donald L. Fry (p. 264)

Nonimpromptu Comment on Papers by Dr. Fry—Robert L. Evans (p. 266)

Blood Flowmeter Utilizing Nuclear Magnetic Resonance—R. L. Bowman and V. Kudravcev (p. 267)

The Potter Electroturbinometer: An Instrument for Recording Total Systemic Blood Flow in the Dog—S. J. Sarnoff and E. Berglund (p. 270)

The flowmeter described is a turbine which can be driven by the bloodstream. In the turbine is a magnet which induces a recordable signal in an adjacent coil. The flowmeter records pulsating flow as well as steady flow; it is insensitive to temperature and wide variations of blood viscosity. The pressure drop is rather high. The base line and calibration are steady over long periods of time. The flowmeter has been successfully used for continuously recording the systemic output in the dog.

An Automatic Recording Bubble Flowmeter—C. W. Nash and J. V. Milligan (p. 274)

Use of Indicator Concentration Curves in Computation of Mean Rate of Flow and Volume of Blood Contained within a Segment of the Vascular System—H. D. Green, *et al.* (p. 277)

Isothermal Blood Flow Velocity Probe—S. Katsura, *et al.* (p. 283)

A New Velocity Probe for Sensing Pulsatile Blood Flow—A. MacDonell Richards (p. 286)

Quantitative Measurement of Branched Flow by Externally Placed Radioisotope Detectors—S. Thompson, *et al.* (p. 287)

Harmonic Analysis of Frequencies in Pulsatile Blood Flow—D. J. Ferguson and H. S. Wells (p. 291)

Critical Review of Bristle Flowmeter Techniques—Gerhard A. Brecher (p. 294)

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Medical Electronics

Vol. ME-7, No. 1, January, 1960

Editorial—Lee B. Lusted (p. 1)

Respiratory Control of Heart Rate: Laws Derived from Analog Computer Simulation—Manfred Clynes (p. 2)

The application of dynamic systems analysis, essential for the design of controlled missiles and of man-made automatic control systems of all kinds, to the control systems within the human organism, is beginning to bear fruit in medical science. These organic control systems, which are part of the living process, generally far surpass any man-made systems in subtlety and ingenuity. Their exploration in terms of feedback control theory is highly instructive both to the medical scientist and to the control engineer, since these systems generally display a quality and perfection of control design several orders of magnitude greater than the human mind can now conceive.

Some aspects of the control of the human heart rate are presented here. Normal and irregular respiration widely changes the rate of the heart from beat to beat. The mathematical laws describing this behavior were derived from analog computer simulation. On the analog computer a mathematical model of the dynamics of the processes involved was created. This was achieved through the use of dynamic data obtained from experiments designed by the help of control theory. These mathematical laws are useful for understanding the operation of the system concerned, and especially valuable for predicting the existence of hitherto unknown structural and organizational relationships, which can be confirmed experimentally.

The electronic analog computer, being fed information about the respiration of the subject, in the form of an electric signal proportional to chest circumference, is able to calculate the timing of the heart beat from beat to beat. The correctness of the predicted heart rate is checked by recording the artificial heart rate simultaneously with the actual heart rate of the subject. The close correspondence of the predicted and actual changes of heart rate for a wide variety of modes of breathing, and for different individuals, proves the validity of the differential equations describing the phenomenon.

Individual variations, as well as the effects of age and of various drugs, are expressible in terms of the parameters of the equations.

Physiologically, the equations clarify the responsible nerve processes. The mathematical description of the reflex control of the heart rate through respiration gives for the first time a quantitative analysis of this phenomenon, which involves the central nervous system. Nerve impulses from at least two different stretch receptors within the chest are sent to the brain, in turn causing nerve impulses from the brain to the heart, along the vagus nerve, to be modified according to definite laws. These laws indicate as a consequence that it is stretch receptors and not haemodynamic factors which are responsible for initiating the changes in heart rate. It is shown further, mathematically, how the pacemaker of the heart responds to various degrees of inhibition produced by the action of the vagus nerve.

The analysis allows the heart rate effects of exercise and emotional stresses, through the action of the autonomic nervous system, to be more precisely perceived as clearly separated from the respiratory effects.

The respiratory effects are shown to be caused by two separate reflexes each producing biphasic heart rate transients in the same directions. The observed effects are the result of superposition of these transients. The variable and often paradoxical results previously observed in attempting to relate heart rate to respiration on a steady-state, nondynamic basis are thus explained.

A New Standardized and Calibrated Phonocardiographic System—A. A. Luisada and R. Zalter (p. 15)

A phonocardiographic system has been designed and built using standard units of known frequency characteristics.

The system is *calibrated*, as the relative and absolute intensity of the signal can be completed from the records' amplitude, given the conversion factor of the transducer and the degree of amplification in decibels. The system is *standardized*. It allows the spectrum to be scanned in bands of 1 octave of 3-db attenuation (therefore ideally flat) with the low-cutoff frequency coinciding with the nominal frequency.

A 36 db per octave attenuation for the high-pass section is suggested for the selective recording of the high-frequency vibration of low intensity. Representative phonocardiographic tracings are presented.

Biological Flow and Process Tracing Using Nuclear and Electron Paramagnetic Resonance—J. R. Singer (p. 23)

A general discussion of the application of nuclear and electron paramagnetic resonance to determination of blood flow velocities in intact humans is discussed. The feasibility has been proven using mice. The system of measurement essentially utilizes paramagnetic (nonradioactive) tracers. One simple tracing scheme which has been employed experimentally is to saturate the protons in the blood stream and detect the density of these protons as variations occur due to flow. By this means the flow velocity is readily measured. A discussion of paramagnetic resonance theory precedes the discussion of the biological applications.

A Pulse Power Amplifier for Biological Stimulation—Harry Ludwig (p. 29)

A power amplifier designed for use as a biological stimulator is described. It is driven by a dc voltage or a pulse generator with an amplitude of 50 volts. The output power of up to 250 volts and 100 ma is precisely controlled. The rise time is less than 5 μsec. A dual-channel version whose outputs may be independently controlled and mixed is also described. The circuit for the +400 volts and −300 volts regulated power supplies is shown.

The Use of Electronic Computers in Medical Data Processing—R. S. Ledley and L. B. Lusted (p. 31)

Some of the potential advantages of computer aids to medical data processing are: making available to the physician quantitative methods in areas relating to data analysis and differential diagnosis; assisting in the evaluation of the best alternative courses of action during stages of the diagnostic testing processes; making easily available to the physician reference to the most current information about new preventive measures, and diagnostic and therapeutic techniques; and periodic recording and evaluating of individual physiologic norms for the more sensitive determination of an individual's health trend relative to disease prevention.

A Unified Concept of Health and Disease—George L. Engel (p. 48)

Military Electronics

Vol. MIL-4, No. 1, January, 1960

Frontispiece and Guest Editorial—Rawson Bennett (pp. 1–2)

Spacious Fantasies—John R. Pierce (p. 3)

Microwaves in the Space Age—H. Richard Johnson (p. 5)

Consideration is given to the direction of future microwave device research and development based on requirements for space communication, tracking, search and surveillance, and interference and countermeasures. The crucial element in two-way communication with a space vehicle is the vehicle-borne transmitter. The large values of one-way transmission loss associated with interplanetary distances will require great improvements in these transmitters. Radar involves two-way transmission loss, so even more improvement will be required for tracking and search radars. Solution of interference problems will require increased instantaneous bandwidths. Accordingly, it is suggested that much additional microwave device research and development work is needed. Average power and efficiency of microwave tubes must be increased, with the longer centimeter wavelengths to be used for earth-based radars and 1–30 millimeter wavelengths to be used for radars to be borne in space vehicles. This work should concentrate mainly on traveling-wave tubes. Solid-state low-noise receiving devices and low-noise traveling-wave tubes must be extended to higher frequencies and broader bandwidths. Means of generating microwave power through the use of plasmas must be investigated. All types of microwave election devices must be adapted to the space environment.

The Role of Radar in Space Research—K. J. Craig, *et al.* (p. 11)

A Radio-Astronomy Project at the University of Illinois—George C. McVittie (p. 14)

High-Altitude Measurements of X Rays and far Ultraviolet Radiation—Herbert Friedman p. (18)

Since 1946, the Naval Research Laboratory has conducted basic research in the physics of the upper atmosphere by means of high-altitude rockets. The program has emphasized all areas of research, including atmospheric structure and composition, the ionosphere, airglow and aurora, meteors, cosmic rays, and rocket astronomy. In the last area, which includes X ray and ultraviolet radiation measurements, NRL scientists have contributed a major portion of the experimental information available today. These comprise all the existing data on solar X rays, the X ray and ultraviolet emissions of solar flares, the first spectrogram of the sun covering the ultraviolet region below 3000 A and subsequent extensions of the spectrum into the extreme ultraviolet, the first quantitative measurements of solar Lyman-α, and the discovery of ultraviolet nebulosities and the Lyman-α glow of the night sky. A recent success in photographing the profile of Lyman-α with very high resolution opens the way to the use of optical resonance absorption as a gauge of atmospheric composition. This method may prove to be a most powerful technique for analysis of the very high atmosphere, well beyond the range of satellite drag measurements. The purpose of this paper is to describe the experimental approach used in accomplishing the radiation measurement program just outlined.

A Gas Cell "Atomic Clock" as a High-Stability Frequency Standard—Maurice Arditi (p. 25)

Precision Optical Tracking of Artificial Satellites—W. F. Hoffmann, *et al.* (p. 28)

Field Emission, A Newly Practical Electron Source—W. P. Dyke (p. 38)

The properties of the field emission electron source are discussed. These include high current density, small size, no heater, instantaneous response, and a highly non-linear current-voltage relationship. Engineering data are then derived including conductance, perveance, beam power, etc. It is shown that the field emission cathode is electrically stable and that it has long life given suitable environments and/or operating conditions which are specifield. Microwave, voltage control and measurement, electron optical and other applications are discussed. A 300-megw flash X-ray tube now in production is described. The availability of the field emitter as a newly practical electron source is expected to make possible a number of new devices which may more often complement than compete with existing technology.

The ONR Program in the Electronics Research Laboratory of the University of California, Berkeley—Samuel Silver (p. 46)

Communication Using Earth Satellites—Jerome B. Wiesner (p. 51)

A review of the use of earth satellites for reliable, ionospheric-independent communication circuits includes considerations of losses in the propagating path, directivity features, and influences such as Doppler shift. The effects of such influences on bandwidth and range are illuminated.

Contributors (p. 58)

Correction

In the Abstracts of IRE Transactions of the December, 1959 issue of PROCEEDINGS OF THE IRE, the article, "The Nesistor—A Semiconductor Negative Resistance," was incorrectly attributed to Robert E. Nelson. The author of the paper, which appeared in the July, 1959 issue of ELECTRON DEVICES, is Robert G. Pohl.

Abstracts and References

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research, London, England, and Published by Arrangement with that Department and the *Electronic and Radio Engineer*, incorporating *Wireless Engineer*, London, England

NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, not to the IRE.

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The number in heavy type at the upper left of each Abstract is its Universal Decimal Classification number. The number in heavy type at the top right is the serial number of the Abstract. DC numbers marked with a dagger (†) must be regarded as provisional.

ACOUSTICS AND AUDIO FREQUENCIES

534.2:621.374.5 **367**

Propagation of Sound in Plate-Shaped Solid Delay Lines—P. M. Sutton. (*J. Acoust. Soc. Amer.*, vol. 31, pp. 34–43; January, 1959.) An analysis by diffraction theory. Quantitative results are compared with experimental data obtained from long plate-shaped fused-Si delay lines.

534.232–8:537.228.1 **368**

Electrical Equivalent Circuits and Vibration Patterns of Barium Titanate Transducers—R. Leisterer. (*Arch. elekt. Übertragung*, vol. 12, pp. 515–526 and 557–561; November and December, 1958.) Equivalent circuits of the elementary cube in the uniaxial and biaxial states of stress, derived from simplified piezoelectric equations, are used to obtain the characteristics and equivalent circuits for thin plate and tubular resonators. Experimental investigations on the latter are described, and optimum dimensions of circular disk resonators are given.

534.232–8:537.228.1 **369**

Ultrasonic Barium Titanate Adhesion and Paste Transducers—A. Lutsch. (*Nature*, vol. 184, pp. 1458–1460; November 7, 1959.) Methods of manufacture of two types of transducer are described and their characteristics are discussed.

A list of organizations which have available English translations of Russian journals in the electronics and allied fields appears at the end of the Abstracts and References section.

534.283–8:546.87 **370**

Ultrasonic Attenuation in Bismuth at Low Temperature—D. H. Reneker. (*Phys. Rev.*, vol. 115, pp. 303–313; July 15, 1959.) Experimental results and interpretation.

534.78 **371**

Intelligibility of Peak-Clipped Speech at High Noise Levels—I. Pollack and J. M. Pickett. (*J. Acoust. Soc. Amer.*, vol. 31, pp. 14–16; January, 1959.) There is no loss of intelligibility when "clean" speech is peak-clipped.

621.395.61 **372**

High-Quality Microphones—M. L. Gayford. (*Proc. IEE*, Part B, vol. 106, pp. 501–513; November, 1959. Discussion, pp. 513–516.) A review of modern practice in the design and operation of high-grade microphones.

621.395.616 **373**

The Uniformity of the Characteristics of a Standard Microphone—T. Hayasaka, M. Suzuki and I. Nakano. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 97–99; April, 1959.) Permissible tolerances in the manufacture of the Type MR-103 condenser microphone are related to deviations from the mean sensitivity curve.

621.395.616.089.6 **374**

Self-Reciprocity Condenser Microphone Calibration—T. Hayasaka, M. Suzuki and R. Araki. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 71–72; March, 1959.) A calibration method is described which uses a single microphone. Results are compared with those obtained with the three-microphone reciprocity method and show a difference within 0.2 db at frequencies below 6 kc and 1.5 db at 10 kc.

621.395.625.3 **375**

Investigation of the Recording Process in Magnetic Sound Recording: Part 1—G. Schwantke. (*Frequenz*, vol. 12, pp. 355–360; November, 1958.) A generalization of Westmijze's model (see, *e.g.*, 1297 of 1954) is derived which is applicable to a wider range of hysteresis-loop shapes. Visual examination of magnetization curves obtained with special apparatus described shows the inadequacy of the theoretical assumptions.

621.395.625.3 **376**

On the Longitudinal Oscillations of Magnetic Recording Tapes—E. Belger and G. Heidorn. (*Rundfunktech. Mitt.*, vol. 3, pp. 51–55; February, 1959.) The characteristics and causes of longitudinal tape oscillations are investigated using the noise sidebands of a sliding tone. Methods of reducing the oscillation are suggested.

ANTENNAS AND TRANSMISSION LINES

621.372 **377**

Diffraction of Surface Electromagnetic Waves at an Impedance Discontinuity—N. G. Trenev. (*Radiotekh. Elektron.*, vol. 3, pp. 27–37; January, 1958.) An investigation of the diffraction of *E* and *H* waves at an impedance discontinuity. Expressions are obtained for the reflection and transmission coefficients. The diffraction field is determined and radiation characteristics are plotted. Diagrams show the radiation at the impedance discontinuity for different values of phase velocity.

621.372.2 **378**

Attenuation of Electromagnetic Waves Propagating along a Wire Helix Line—S. Kh. Kogan. (*Radiotekh. Elektron.*, vol. 4, pp. 181–186; February, 1959.) A characteristic equation is derived showing the dependence of the propagation constant on helix geometry and wavelength.

621.372.8 **379**

On the Theory of Tapered Waveguides—V. L. Pokrovskiĭ, F. P. Ulinich and S. K. Savvinykh. (*Radiotekh. Elektron.*, vol. 4, pp. 161–171; February, 1959.) Investigation of em wave propagation in a plane waveguide with finitely small degree of tapering. By combining the perturbation theory with the WKB method, it is possible to compute the reflection and scattering effects to any degree of approximation of a small parameter. Reflection and scattering depend to a large extent on the smoothness of the taper.

621.372.8:621.39:061.3 **380**

Long-Distance Transmission by Waveguide—(*Proc. IEE*, Part B, vol. 106, suppl. no. 13, pp. 1–199; 1959.) The text is given of papers presented at the IEE Convention held in London, January 29 and 30, 1959.

621.372.83 **381**

Overmoded Waveguides—L. Solymar. (*Electronic Radio Eng.*, vol. 36, pp. 426–428; November, 1959.) Assuming the perturbation of the electric field negligible, a general expression is derived for the amplitudes of the spurious modes generated at the discontinuity between a circular waveguide supporting the H_{01} mode and a noncircular one. It is seen that no *E* modes are excited at the discontinuity.

621.372.83 **382**

Reflections at Waveguide Flange Joints—U. v. Kienlin and A. Kurzl. (*Nachrichtentech.*

Z., vol. 11, pp. 561–564; November, 1958.) The effects of misalignment, such as offset and twist, between sections of rectangular waveguide and of discontinuities in cross section due to manufacturing tolerances are discussed. The maximum reflections possible under German and U. S. manufacturing standards are estimated.

621.372.832.8 383

***E*-Type X Circulator**—S. Yoshida. (Proc. IRE, vol. 47, pp. 2017–2018; November, 1959.) The circulator comprises a ferrite element in an *E*-type four-port rectangular waveguide junction.

621.372.832.8 384

An *E*-Type *T* Circulator—S. Yoshida. (Proc. IRE, vol. 47, p. 2018; November, 1959.) The device has a ferrite element in an ordinary *E*-type *T* junction.

621.372.85 385

The Effect of a Dielectric Film on the Attenuation of the H_{01} Wave in a Rectilinear Quasicircular Waveguide—B. Z. Katsenelenbaum. (*Radiotekh. Elektron.*, vol. 3, pp. 38–45; January, 1958.) Calculation of the additional attenuation of H_{0m} waves produced by a thin semiconducting film located on the inside surface of a circular waveguide. The analysis of waveguides of almost circular cross section is generalized to that of irregular rectilinear waveguides.

621.372.85 386

Symmetrical Diaphragm of Arbitrary Thickness in a Circular Waveguide—M. V. Butrov. (*Radiotekh. Elektron.*, vol. 3, pp. 56–60; January, 1958.) A mathematical analysis of the effect of the round aperture of the diaphragm on the passage of H_{01}-type waves.

621.372.85 387

Propagation of Electromagnetic Waves in Loaded Bent Waveguides—A. N. Didenko. (*Radiotekh. Elektron.*, vol. 4, pp. 172–180; February, 1959.) Dispersion equations and field expressions are derived and various waveguide systems are considered in relation to their application in particle accelerators.

621.372.852.22 388

A Ferrite Boundary-Value Problem in a Rectangular Waveguide—L. Lewin. (*Proc. IEE*, Part B, vol. 106, pp. 559–563; November, 1959.) A solution is given for the reflection of an electromagnetic wave from a transversely magnetized ferrite block in a rectangular waveguide.

621.396.67:537.226 389

A Variational Expression for the Terminal Admittance of a Semi-Infinite Dielectric Rod—C. M. Angulo and W. S. C. Chang. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 207–212; July, 1959. Abstract, Proc. IRE, vol. 47, pp. 2036–2037; November, 1959.)

621.396.677 390

Optimum Linear Co-Phased Aerials with Continuous Current Distribution—I. F. Sokolov and D. E. Bakman. (*Radiotekh. Elektron.*, vol. 3, pp. 46–55; January, 1958.) A mathematical analysis based on Dolph's investigation of current distribution for broadside arrays (2487 of 1946) which optimizes the relation between beamwidth and size of the sidelobes. Formulas for the determination of directivity diagrams and the current amplitude distribution are derived, and optimum and quasi-optimum directivity diagrams for different sidelobes are shown.

621.396.677.029.55 391

A Multiple-Direction Universally-Steerable Aerial System for H.F. Operation—D. W. Morris and G. Mitchell. (*Proc. IEE*, Part B, vol. 106, pp. 555–558; November, 1959.) The antenna can be steered in both azimuth and elevation. It comprises a number of omnidirectional unit antennas with the outputs (in the receiving condition) arranged to be in phase for any desired combination of frequency and direction.

621.396.677.3 392

On the Phase Velocity of Wave Propagation along an Infinite Yagi Structure—D. L. Sengupta. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 234–239; July, 1959. Abstract, Proc. IRE, vol. 47, p. 2037; November, 1959.)

621.396.677.3:621.396.965 393

An Investigation of the Complex Mutual Impedance between Short Helical Array Elements—A. R. Stratoti and E. J. Wilkinson. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 279–280; July, 1959.)

621.396.677.7:621.372.826 394

A Note on Surface Waves along Corrugated Structures—L. O. Goldstone and A. A. Oliner. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 274–276; July, 1959.) Comment on a paper by Hougardy and Hansen (3201 of 1959).

621.396.677.7:621.372.826 395

Comments on "Scanning Surface-Wave Antennas—Oblique Surface Waves over a Corrugated Conductor"—R. E. Collin: R. W. Hougardy and R. C. Hansen. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 276–277; July, 1959.) See 394 above.

621.396.677.71 396

Radiation from Slot Arrays on Cones—R. F. Goodrich, R. E. Kleinman, A. L. Maffett, C. E. Schensted, K. M. Siegel, M. G. Chernin, H. E. Shanks and R. E. Plummer. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 213–222; July, 1959. Abstract, Proc. IRE, vol. 47, p. 2037; November, 1959.)

621.396.677.833:621.396.965 397

A Study of Spherical Reflectors as Wide-Angle Scanning Antennas—T. Li. IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 223–226; July, 1959. Abstract, Proc. IRE, vol. 47, p. 2037; November, 1959.)

621.396.677.833.1 398

Analysis and Reduction of Scattering from the Feed of a Cheese Antenna—W. A. Cumming, C. P. Wang and S. C. Loh. (IRE Trans. on Antennas and Propagation, vol. AP-7. pp. 226–233; July, 1959. Abstract, Proc. IRE, vol. 47, p. 2037; November, 1959.)

621.396.677.85 399

A Method to Achieve a Collimated Circularly Polarized Beam—C. L. Gray and J. C. Huber, Jr. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 281–282; July, 1959.) Description of a lens which may be used with any linearly polarized source such as a waveguide horn.

AUTOMATIC COMPUTERS

681.142 400

The Simulation of Equations with Analogue Computers—H. Schuchardt. *VDI Zeitschrift*, vol. 101, pp. 1053–1063; August 1, 1959.) Detailed description of the principles of operation of the various computer elements giving examples of programming and computation with reference to an American electronic analog computer.

681.142:517.9 401

Some Aspects of the Logical and Circuit Design of a Digital Field Computer—I. F. Brown and B. Meltzer. (*Electronic Engrg.*, vol. 31, pp. 590–592; October, 1959.) A new type of digital computer for the solution of field problems is described. By making calculations at all the lattice points of the field simultaneously, computation time is greatly reduced. An experimental design of a basic unit for potential and other problems is presented. See 3354 of 1958 (Meltzer and Brown).

681.142:621.318.042 402

The AC Writing Method for Magnetic Core Matrices—S. Yamada and T. Bessho. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 44–47; February, 1959.) Description of a writing method suitable for operation in a system using parametron devices. Two alternating currents of frequency *f* and *f*/2 respectively produce an asymmetrical field in a toroidal core. One of the writing currents is also used for reading. See also 410 below.

681.142:621.318.57 403

Function Generation with Operational Amplifiers—H. Koerner and G. A. Korn. (*Electronics*, vol. 32, pp. 66–68, 70; November 6, 1959.) Errors in analog computers caused by diode limiters can be reduced by using accurate electronic switches with high-gain dc amplifiers and voltage feedback. Applications of the techniques for comparators, multivibrators and integrator reset circuits are described and future applications are indicated.

681.142:621.372.44 404

Reading of Recorded Signals with a Low-Frequency Parametron—K. Zen'iti and K. Nisiguit. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 48–53; February, 1959.) Description of a tape recording system in which parametron devices replace tubes. To increase the storage capacity, some form of multiplex system is required.

681.142:621.395.625.3 405

High-Density Recording on Magnetic Tape—A. Gabor. (*Electronics*, vol. 32, pp. 72–75; October 16, 1959.) A self-clocking technique is used to by-pass problems of digital recording at a density of 1500 bits. High reliability is obtained with no information drop-out.

681.142:681.188 406

The Application of a Pattern-Recognition Technique to the Synthesis of Coding Circuits—J. H. Calderwood and A. Porter. (*J. Electronics Control*, vol. 6, pp. 556–566; June, 1959.) If the coding processes considered are regular and predictable, then corresponding translating circuits can be determined. To illustrate the technique a pattern-recognition method is applied to two coding problems.

681.142:681.188 407

The Synthesis of a Parallel Adder Circuit using a Pattern-Recognition Technique—J. H. Calderwood and A. Porter. (*J. Electronics Control*, vol. 6, pp. 567–576; June, 1959.) Besides the synthesis, a comparison with a conventional adder circuit is given. See 406 above.

681.142:681.42.002.2 408

Lens Designing by Electronic Digital Computer: Part 2—M. Nunn and C. G. Wynne. (*Proc. Phys. Soc.*, vol. 74, pp. 316–329; September 1, 1959.) A description of the program used and the results achieved. **Part 1**—2483 of 1959 (Wynne).

CIRCUITS AND CIRCUIT ELEMENTS

621.3.049.7 409

Miniaturization and Micro-Miniaturization—G. W. A. Dummer. (*Wireless World*, vol. 65, pp. 545–549; December, 1959.) Description of new techniques giving increased reliability together with a preliminary evaluation of their performance compared with existing techniques.

621.318.57:621.372.44 **410**

Signal Converter by Magnetic Cores for Parametron Device—K. Hanawa and K. Kusunoki. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 25–31; February, 1959.) Input signals for a parametron device [see 3588 of 1959 (Goto)] may be switched using ferromagnetic cores whose permeability is controlled by direct voltage.

621.318.57:621.382.3 **411**

Transistor Switching Speed—P. M. Thompson and J. Bateson. (*Wireless World*, vol. 65, pp. 530–533; December, 1959.) Theoretical treatment of the limitations of transistors in high-speed switches, together with some methods of improving performance by decreasing switching time.

621.319.4:537.529 **412**

The Breakdown Strength of Capacitors—H. Veith. (*Frequenz*, vol. 12, pp. 348–353; November, 1958.) A formula for breakdown field strength is derived which contains the coefficient of thermal conductivity, the dielectric constant, and a factor giving carrier mobility.

621.319.4.004.6 **413**

The Temperature and Voltage Dependence of the Length of Life of Capacitors—H. Veith. (*Frequenz*, vol. 12, pp. 353–355; November, 1958.) The process of deterioration of the dielectric material under various operating conditions is discussed on a theoretical basis (see 412 above) and with reference to life tests on paper capacitors.

621.372.5 **414**

Contribution to the Theory of General Quadripoles—O. Heymann. (*Arch. elekt. Übertragung*, vol. 12, pp. 488–496; November, 1958.) The matrix characteristics of general linear quadripoles are investigated, and a strict definition of a lossless quadripole is given. An equivalent circuit of the quadripole formed by three partial quadripoles connected in tandem is derived; matching problems and a formula for power gain are discussed.

621.372.54 **415**

Design of Attenuators of Given Characteristics—U. Kirschner. (*Elektron. Rundschau*, vol. 12, pp. 412–414; December, 1958.) Design formulas for quadripole attenuating networks are tabulated.

621.372.54 **416**

A Recriprocal Theorem on Quasilinear Wave Filters—A. W. Thies. (*J. Inst. Eng. (Australia)*, vol. 31, pp. 243–246; October/November, 1959.) Under certain conditions, the power of an intermodulation product measured at one pair of terminals of a filter equals that measured at the other pair when all signals are transmitted in the opposite direction but at unchanged levels.

621.372.54:621.373.1 **417**

Electromechanical Filters for Use in Telecommunication Equipment—G. L. Grisdale. (*Brit. Commun. Electronics*, vol. 6, pp. 768–772; November, 1959.) Includes descriptions of construction and performance of reed-type, magnetostrictive and piezoelectric filters.

621.372.543.2:538.652 **418**

A Practical Electromechanical Filter—H. Bache. (*Marconi Rev.*, vol. 22, pp. 145–153; 3rd Quarter, 1959.) Details of materials and fabrication techniques are given for narrow-band 1 mw torsional filters in the 100–500-kc range.

621.372.543.2:538.652 **419**

A Theoretical Analysis of the Torsional Electromechanical Filters—W. Struszynski. (*Marconi Rev.*, vol. 22, pp. 119–143; 3rd Quarter, 1959.) The mechanical properties of a torsional system are expressed in terms of electrical equivalents. By introducing a "transducer transfer ratio" with the dimensions of charge, a method is developed for the design of electromechanical filters based on equivalent electrical networks. Pass band ripple, spurious modes and transducer matching are discussed.

621.373.018.41–52:621.374.32 **420**

Digital Input for Precision Variable Oscillators—N. G. Alexakis. (*Electronics*, vol. 32, pp. 56–57; October 30, 1959.) Details are given of a signal generator for the frequency range 1 cps–1 mc. The drive unit is a voltage-controlled oscillator regulated by the difference in width between standard 1-second pulses and pulses whose duration is that of the time required for the oscillations fed to a counter unit to equal a preset number. Successive sampling at intervals of 1.11 second ensures errors less than 0.01 per cent.

621.373.2 **421**

A Method of Generating Pairs of Millimicrosecond Current Pulses Separated by a Variable Interval—J. M. Somerville. (*Proc. Phys. Soc.*, vol. 74, pp. 378–379; September 1, 1959.) The first pulse is formed by the discharge of a coaxial line L through a spark gap into a variable length section of identical line L_1. A second pulse is produced by the return of the first pulse after reflection at the short-circuited end of L_1. Further reflections from the other end of L are prevented by a clipping tube.

621.373.42 **422**

Frequency-Stable Oscillators for Current and Voltage—W. Herzog. (*Nachrichtentech. Z.*, vol. 11, pp. 550–556; November, 1958.) The suitability of bridge-type oscillators as current or voltage source under optimum frequency-stability conditions is discussed.

621.373.421 **423**

Wien-Bridge Oscillators—D. E. D. Hickman. (*Wireless World*, vol. 65, pp. 550–555; December, 1959.) Theoretical analysis of Wien-bridge oscillators and procedure for practical design, together with an example of thermistor stabilization.

621.373.443 **424**

Pulse Modulators using Transistors and Switching Reactors—B. F. C. Cooper and W. J. Payten. (*Proc. IRE (Australia)*, vol. 20, pp. 148–152; March, 1959.) A regenerative circuit is described which uses a power transistor to control the charging of a pulse-forming network through a transformer with a sharply saturating core.

621.373.52 **425**

Point-Contact Transistor Relaxation Oscillators—V. N. Iakovlev. (*Radiotekh. Elektron.*, vol. 3, pp. 61–73; January, 1958.) The plotting of phase curves for oscillators with emitter-collector and collector capacitance are shown and possible operating modes investigated. Expressions are given for deriving the pulse parameters. Conditions are expressed for the appearance of step discontinuities as well as for a self-oscillatory mode.

621.374.3:621.3.018.7 **426**

Approximate Waveform Solutions for Diodes in Pulse Circuits—D. C. Dillistone. (*Electronic Engrg.*, vol. 31, pp. 607–610; October, 1959.) With an approximate representation of a diode, solutions are obtained for the response of simple circuits to a rectangular-wave input. Applications of the results are discussed.

621.374.32:621.376 **427**

An Investigation into some Aspects of Diode Quantizing Circuits—H. V. Bell and W. Alexander. (*Electronic Engrg.*, vol. 31, pp. 594–598; October, 1959.) Quantization is defined and work in the field is reviewed. Three circuits are compared theoretically and by measurement, and possible applications are described.

621.374.4:621.373.3.029.64 **428**

Harmonic Generation in a Cyclotron Resonant Plasma—R. M. Hill and S. J. Tetenbaum. (*J. Appl. Phys.*, vol. 30, pp. 1610–1611; October, 1959.) The harmonic conversion efficiencies are comparable to those for crystals and, over the same power range, superior to those for ferrite multipliers.

621.374.44:621.382.3 **429**

A Transistor Blocking-Oscillator Frequency Divider—F. Butler. (*Electronic Engrg.*, vol. 31, pp. 611–612; October, 1959.) This includes the design of a "staircase" waveform generator in which all the voltage increments are equal in amplitude.

621.375.018.75 **430**

Design of Pulse Amplifier—R. C. Ganguli. (*Indian J. Phys.*, vol. 33, pp. 263–275; June, 1959.) A relation between gain, overshoot and risetime is derived and applied in the design of a single-stage tube amplifier.

621.375.2.018.7 **431**

Distortion in Pentode Voltage Amplifiers—R. E. Aitchison, C. T. Murray and I. S. Docherty. (*Proc. IRE (Australia)*, vol. 20, pp. 147–148; March, 1959.) Characteristics are given which show that, for a fixed screen voltage, the distortion varies rapidly with changes in grid bias, while, if the screen voltage is supplied via a series resistance, there is a compensating action which maintains the distortion at an almost constant value.

621.375.223 **432**

RC Amplifier with 60-mc/s Bandwidth—K. J. Schmidt-Tiedemann. (*Elektron. Rundschau*, vol. 12, pp. 414–416; December, 1958.) The effect of stray capacitance is compensated by a cathode-follower circuit. In the two-stage circuit described a gain of 5.3 is achieved for a bandwidth of 62 mc.

621.375.227 **433**

Cathode-Coupled Push-Pull Output Stage—K. R. Sturley and J. P. Bennett. (*Electronic Radio Eng.*, vol. 36, pp. 410–415; November, 1959.) A theoretical investigation of linear operation shows that for large common-cathode resistances, R_k, the ratio of anode currents in each tube approximates to unity and their magnitude is almost independent of R_k. This is confirmed experimentally, and measurements of power output and distortion are obtained for different values of R_k.

621.375.3 **434**

How Magnetic Amplifier controls Transconductance—C. C. Whitehead. (*Electronics*, vol. 32, pp. 84–87; November 13, 1959.) See 2170 of 1959.

621.375.4:621.396 **435**

Transistor Amplifiers for Sound Broadcasting—S. D. Berry. (*B.B.C. Engrg. Monographs*, no. 26, 19 pp.; August, 1959.) The application of Ge *p-n-p* junction transistors to various types of high-quality amplifiers is described. An assessment is made of the suitability of transistors for this field.

621.375.4.029.4/5 **436**

Transistors in Low-Frequency Amplifiers—W. Langsdorff and W. Heberle. (*Frequenz*, vol. 12, pp. 337–348; November, 1958.) Design formulas are derived and the relations between circuit parameters for the three basic transistor configurations are tabulated. The main types of feedback and their effects are discussed.

621.375.9:537.56:538.56 437

Possible Low-Noise Electron-Beam Plasma Amplifier—Anderson. (See 455.)

621.375.9:538.569.4.029.64 438

Cavity Maser Experiments using Ruby at *S*-Band—W. S. C. Chang, J. Cromack and A. E. Siegman. (*J. Electronics Control*, vol. 6, pp. 508–526; June, 1959.) A three-level solid-state maser was used at frequencies near 3 kmc. Pumping at 13.5 kmc gave a gain-bandwidth product of over 50 mc. Another mode of operation with pumping at 23.7 kmc is capable of increasing this product substantially.

621.375.9:538.569.4.029.64 439

A Double Pumping Scheme Applicable to Low-Frequency Masers—J. E. King, A. Birko and G. Makhov. (Proc. IRE, vol. 47, p. 2025; November, 1959.) Note on a "parallel" pumping system of importance for low-frequency operation of a ruby maser.

621.375.9:621.382.2 440

Semiconductor Varactors using Surface Space-Charge Layers—Pfann and Garrett. See (689.)

621.375.9:621.382.2 441

Alloyed, Thin-Base Diode Capacitors for Parametric Amplification—K. E. Mortenson. (*J. Appl. Phys.*, vol. 30, pp. 1542–1548; October, 1959.) The design principles are given; maximum Q-values of the order 200 at 1 kmc have been obtained with capacitive swings greater than 10.

621.375.9:621.383:535.376 442

Electroluminescent Cell Applications—R. B. Lochinger and M. J. O. Strutt. (*Electronic Radio Eng.*, vol. 36, pp. 398–406; November, 1959.) An account of investigations of the combination of electroluminescent cells and photoreceptors as elements in amplifier, oscillator, demodulation-amplifier, and bistable multivibrator circuits. Measurements of the variation of efficiency with frequency and a theoretical analysis of photoconductor amplifier time-constants are also given.

621.376.4 443

Diode Phase-Sensitive Detectors with Load—R. Chidambaram and S. Krishnan. (*Electronic Engrg.*, vol. 31, pp. 613–616; October, 1959.) A theoretical and experimental investigation of the nonlinearity introduced by loading a simple diode push-pull phase detector.

GENERAL PHYSICS

530.12:531.18:621.3.018.41(083.74) 444

A New Experimental Test of Special Relativity—J. P. Cedarholm and C. H. Townes. (*Nature*, vol. 184, pp. 1350–1351; October 31, 1959.) The experiment is based on comparing the frequencies of two NH_3-beam masers mounted with oppositely directed beams on a rack which may be rotated through 180° about a vertical axis. A precision of one part in 10^{12} has been achieved in this frequency comparison, from which the upper limit on an ether drift of 1/1000 of the earth's orbital velocity may be set.

535.62 445

Two-Coordinate Colour—M. H. Wilson and R. W. Brocklebank. (*Electronic Radio Eng.*, vol. 36, p. 429; November, 1959.) Comment on 3629 of 1959 with reference to other work on the subject.

537.311.1 446

On the Screening of Impurity Potential by Conduction Electrons—N. Takimoto. (*J. Phys. Soc. Japan*, vol. 14, pp. 1142–1158; September, 1959.) A modified Thomas-Fermi method is used to calculate the impurity potential, and it is shown that similar results are obtained by the method of Nakajima and Bardeen and Pines (see 379 of 1956).

537.525:621.372.413 447

The Effect of Field Configuration on Gas Discharge Breakdown in Microwave Cavities at Low Pressure—S. A. Self and H. A. H. Boot. (*J. Electronics Control*, vol. 6, pp. 527–547; June, 1959.) A new regime of gas discharge breakdown in microwave cavities is shown to be due to gradients in the electric field amplitude. Experimental results are given.

537.533 448

Necessary and Sufficient Trajectory Conditions for Dense Electron Beams—W. M. Mueller. (*J. Electronics Control*, vol. 6, pp. 499–507; June, 1959.) Gives conditions for flow in the direction of one coordinate in a number of coordinate systems.

537.533 449

Two Alternative Definitions of Small-Signal RF Power of Electron Beams—E. L. Chu. (*J. Appl. Phys.*, vol. 30, pp. 1617–1618; October, 1959.) Lagrangian or Eulerian definition is chosen according to the type of problem or method of calculation.

537.533 450

Comments on Klüver's Paper entitled "Small-Signal Power Conservation Theorem for Irrotational Electron Beams"—E. L. Chu. (*J. Appl. Phys.*, vol. 30, pp. 1618–1619; October, 1959.) See 2703 of 1958.

537.56 451

Measurement of Plasma Temperature and Electron Density—K. Murakawa and S. Mizuno Hashimoto. (*J. Phys. Soc. Japan*, vol. 14, pp. 1235–1242; September, 1959.) The plasma temperature and electron density were obtained from a comparison of the wavelength of the line NE I λ5852 emitted from an arc discharge and from a condensed spark discharge.

537.56 452

Electron and Ion Runaway in a Fully Ionized Gas: Part 1—H. Dreicer. (*Phys. Rev.*, vol. 115, pp. 238–249; July 15, 1959.) Hydrodynamic equations are used to describe the flow of the electrons and ions of a fully ionized gas under the action of an electric field of arbitrary magnitude.

537.56:061.3 453

Ionization Phenomena in Gases—J. Dutton, D. Harcombe and E. Jones. (*Nature*, vol. 184, pp. 1353–1358; October 31, 1959.) Report of a conference at Uppsala, Sweden, August 17, 1959.

537.56:538.56 454

Effect of Relatively Strong Fields on the Propagation of E. M. Waves, through a Hypersonically Produced Plasma—W. B. Sisco and J. M. Fiskin. (IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 240–244; July, 1959. Abstract, Proc. IRE, vol. 47, p. 2037; November, 1959.)

537.56:538.56:621.375.9 455

Possible Low-Noise Electron-Beam Plasma Amplifier—J. M. Anderson. (*J. Appl. Phys.*, vol. 30, pp. 1624–1625; October, 1959.) Low-noise amplification of space-charge waves should be achieved by interaction between electron beam and plasma in the negative-glow region of a cold-cathode discharge.

537.56:538.69 456

Plasma Configurations with Surface Currents which are Held in Equilibrium by a Magnetic Field—R. Kippenhahn. (*Z. Naturforsch.*, vol. 13a, pp. 260–267; April, 1958.) The conditions for the existence of various plasma configurations in equilibrium with an external magnetic field are investigated.

538.1 457

Remarks on Magnetically Dilute Systems—H. Sato, A. Arrott and R. Kikuchi. (*J. Phys. Chem. Solids*, vol. 10, pp. 19–34; April, 1959.) A re-examination of the problem using an Ising model.

538.3 458

A Scalar Representation of Electromagnetic Fields: Part 3—P. Roman. (*Proc. Phys. Soc.*, vol. 74, pp. 281–289; September 1, 1959.) Gives transformation properties and the physical energy-momentum tensor appropriate to Green and Wolf's theory (1739 of 1954).

538.3 459

A Scalar Representation of Electromagnetic Fields: Part 2—E. Wolf. (*Proc. Phys. Soc.*, vol. 74, pp. 269–280; September 1, 1959.) Extends work in an earlier paper [1739 of 1954 (Green and Wolf)] to deal with energy transport.

538.566:535.42 460

Diffraction of a Dipole Field by a Unidirectionally Conducting Semi-Infinite Screen—J. Radlow. (*Quart. Appl. Math.*, vol. 17, pp. 113–127; July, 1959.) An exact solution of the diffraction problem for a dipole is obtained.

538.566:535.42 461

Diffraction of Electromagnetic Waves in a Band of Finite Width—G. A. Grinberg. (*Dokl. Akad. Nauk SSSR*, vol. 129, pp. 295–298; November 11, 1959.) Brief mathematical analysis based on a new method for solving integral equations similar to the Fredholm equations. An asymptotic form of the required solution for $\gamma > 1$ is obtained, where γ is a function of the number of waves and of the bandwidth.

538.569:539.2 462

Induced and Spontaneous Emission in a Coherent Field: Part 2—I. R. Senitzky. (*Phys. Rev.*, vol. 115, pp. 227–237; July 15, 1959.) "The interaction between the electromagnetic field and a number of identical atomic systems, individually characterized by an electric dipole moment and two energy levels, is analyzed for the case where the atomic systems are inside a lossy cavity and exposed to a coherent driving field, resonance being assumed between atomic system, cavity, and driving field." Part 1—3777 of 1958.

538.569.4.029.6:535.343.9:537.228.5 463

100-kc/s Square-Wave Modulator and Receiver for Stark-Effect Microwave Spectrometers—H. G. Fitzky. (*Z. angew. Phys.*, vol. 10, pp. 489–495; November, 1958.)

539.2:538.1 464

Superexchange Interaction and Symmetry Properties of Electron Orbitals—J. Kanamori. (*J. Phys. Chem. Solids*, vol. 10, pp. 87–98; July, 1959.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.164 465

A Search for Neutral Atomic Hydrogen in Globular Clusters—M. S. Roberts. (*Nature*, vol. 184, suppl. no. 20, pp. 1555–1556; November 14, 1959.) Results of measurements of the 21-cm emission of two globular clusters *M3* and *M13* are discussed.

523.164:523.165 466

The Relation of Cosmic Radio Emission to

the Electronic Component of Cosmic Rays—H. Tunmer. (*Monthly Notices Royal Astron. Soc.*, vol. 119, no. 2, pp. 184–193; 1959.) The similarity between the spectra of cosmic rays and of the relativistic electrons responsible for cosmic radio waves suggests that the electrons may derive from the collisions of primary cosmic rays with the interstellar gas. The relation to be expected from this process is examined.

523.164.3 **467**

The Brightness Distribution within the Radio Sources Cygnus A (19N4A) and Cassiopeia A (23N5A)—R. C. Jennison and V. Latham. (*Monthly Notices Royal Astron. Soc.*, vol. 119, no. 2, pp. 174–183; 1959.) A description of the results obtained with a three-station interferometer system operating at 127 mc.

523.164.3 **468**

The Source of Radiation from Jupiter at Decimetre Wavelengths—G. B. Field. (*J. Geophys. Res.*, vol. 64, pp. 1169–1177; September, 1959.) Electrons from the sun which are trapped in Jupiter's magnetic field may be the source.

523.164.32 **469**

Radio Emission in the Outer Corona—W. C. Erickson. (*Phys. Rev. Lett.*, vol. 3, pp. 365–367; October 15, 1959.) During May, June and July transit observations of the sun were obtained at a frequency of 26.3 mc at Clark Lake radio-astronomy station. The height of the radio emission appears to have been 4–5 solar radii early in May.

523.164.32:523.746 **470**

Correlation between the Intensity of the Umbra of Sunspots and Enhanced Radiation on 200 Mc/s—P. Maltby. (*Nature*, vol. 184, suppl. no. 18, p. 1391; October 31, 1959.) From observations made in Norway since April, 1959, a high correlation is shown to exist between the darkness of the umbra and the noise activity of sunspots.

523.164.32:550.385.4 **471**

Geomagnetic Disturbance and Velocity of Slow-Drift Solar Radio Bursts—M. B. Wood and C. S. Warwick. (*Nature*, vol. 184, suppl. no. 19, pp. 1471–1472; November 7, 1959.) Frequency drift rates of type-II bursts, determined from radio spectral observations, indicate a systematically greater acceleration for the sources of bursts which are followed by geomagnetic disturbance.

523.164.4:535.221 **472**

A Radio-Astronomical Test of the Ballistic Theory of Light Emission—L. R. O. Storey and R. S. Lawrence. (*Observatory*, vol. 79, pp. 150–151; August, 1959.) A comparison between optical and radio-interferometer measurements of the declination of radio star Cygnus-A is put forward as proof that the ballistic theory of light emission [see, *e.g.*, *Monthly Notices Royal Astron. Soc.*, vol. 119, no. 1, pp. 67–71; 1959 (Dingle)] is untenable.

523.165 **473**

On the Possibility of Detecting Synchrotron Radiation from Electrons in the Van Allen Belts—R. B. Dyce and M. P. Nakada. (*J. Geophys. Res.*, vol. 64, pp. 1163–1168; September, 1959.) The equipment suggested is a 30-mc polarimeter at the magnetic equator, using an antenna directed vertically upward.

523.165 **474**

Proton Component of the Primary Cosmic Radiation—F. B. McDonald and W. R. Webber. (*Phys. Rev.*, vol. 115, pp. 194–205; July 1, 1959.) The proton component has been studied at high altitudes on a series of balloon flights at various latitudes using the Čerenkov scintillation-counter technique. Results are discussed.

523.165 **475**

Unusual Cosmic-Ray Fluctuations on July 17 and 18, 1959—H. Carmichael and J. F. Steljes. (*Phys. Rev. Lett.*, vol. 3, pp. 392–394; October 15, 1959.) A large Forbush decrease of cosmic-ray intensity which coincided with a magnetic storm exhibited rapid changes of neutron intensity, at the rate of 7 per cent in 20 minutes. It is difficult to account for these changes on the basis of existing theories of the modulation of cosmic radiation.

523.165 **476**

North-South Anisotropy and Anticipatory Increase of Intensity associated with the Cosmic-Ray Storm of February 11, 1958—V. Sarabhai and R. Palmeira. (*Nature*, vol. 184, pp. 1204–1207; October 17, 1959.) An analysis of cosmic-ray data obtained from a high-counting-rate meson detector and a grid of neutron monitor stations during the period February 9–12, 1958. Other effects associated with the storm are discussed.

523.165:523.75 **477**

Observations of Low-Energy Solar Cosmic Rays from the Flare of 22 August 1958—K. A. Anderson, R. Arnoldy, R. Hoffman, L. Peterson and J. R. Winckler. (*J. Geophys. Res.*, vol. 64, pp. 1133–1147; September, 1959.)

523.165:523.75 **478**

Observations of Solar Flare Radiation at High Latitude during the Period July 10–17, 1959—R. R. Brown and R. G. D'Arcy. (*Phys. Rev. Lett.*, vol. 3, pp. 390–392; October 15, 1959.) Cosmic-ray detectors, consisting of photon counters, were borne aloft by clusters of sounding balloons. Curves showing variations of intensity with atmospheric depth are given for quiet conditions and under solar-flare conditions. The results are analyzed.

523.42:621.396.96 **479**

Radio Echo Observations of Venus—J. V. Evans and G. N. Taylor. (*Nature*, vol. 184, pp. 1358–1359; October 31, 1959.) A description of the equipment used and a discussion of the results of observations at Jodrell Bank on 408 mc during September, 1959. No echoes stronger than the noise level of the receiver were observed; an analysis of the signals received was therefore made with integrating equipment and the results compared with those of Price, *et al.* (2556 of 1959).

523.5:621.396.9 **480**

The Effect of Trail Irregularities on the Interpretation of Meteor Echoes—A. G. McNamara and D. W. R. McKinley. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 156–159; October, 1959.) "A brief discussion of some points raised in a recent paper by Manning (2225 of 1959) on obliquely-scattered meteor echoes is followed by the suggestion that the initial distribution of ionization along a typical meteor trail is markedly irregular. Several tentative hypotheses are advanced to account for the irregularities."

523. 755:523.164 **481**

The Inner Solar Corona during June 1959—G. A. Newkirk, G. W. Curtis, D. K. Watson, R. Manning and J. Shelby. (*Nature*, vol. 184, suppl. no. 17, pp. 1308–1309; October 24, 1959.) An analysis of observations with the K-coronameter at Climax, Colorado, of the Taurus-A radio source.

550.385:523.78 **482**

On the Variation in the Horizontal Intensity of the Geomagnetic Field at Phalodi (Rajasthan) during the Solar Eclipse of 30 June 1954—B. J. Srivastava and N. S. Sastri. (*Indian J. Meteorol. Geophys.*, vol. 10, pp. 73–84; January, 1959.) A detailed study of horizontal field variations during the period June 22 to July 7, 1954, indicates that a fall of 10γ 16 minutes after totality may not be an eclipse effect. The results therefore do not confirm those of Egedal and Ambolt (107 of 1956).

550.385.2 **483**

Variations in the Geomagnetic Field at Ibadan, Nigeria: Parts 1 and 2—C. A. Onwumechilli and N. S. Alexander. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 106–123; October, 1959.) Magnetic records have been analyzed for the period November, 1955–June, 1957 to detect solar and lunar terms in the variations of the usual magnetic components. Amplitude variations of H and Z for both terms are about three times larger than for stations which have the same geographic latitude but which are not near the magnetic equator. These large variations are attributed to the electrojet. The solar variations of D show no such obvious effect.

551.507.362.2 **484**

Effects of the Earth's Oblateness on the Orbit of an Artificial Satellite—A. de Moraes. (*Ann. acad. brasil. sci.*, vol. 30, pp. 465–510; December 31, 1958. In English.) A mathematical analysis of the perturbations of the radius vector, the displacement of the modal and apsidal lines and the variation of the inclination with latitude. A rigorous solution to the second-order differential equation is given for an equatorial orbit taking account of the first-order effects of the earth oblateness. Some second-order effects on the equatorial orbit and the relativistic effect of the apsidal-line displacement are considered.

551.507.362.2 **485**

Density of the Upper Atmosphere from Analysis of Satellite Orbits: Further Results—D. G. King-Hele. (*Nature*, vol. 184, pp. 1267–1270; October 24, 1959.) A method described earlier (2955 of 1959) has been refined to take into account atmospheric rotation.

551.507.362.2:551.510.535 **486**

The Ion-Trap Results in "Exploration of the Upper Atmosphere with the Help of the Third Soviet Sputnik"—E. C. Whipple, Jr. (PROC. IRE, vol. 47, pp. 2023–2024; November, 1959.) The interpretation of the data given by Krassovsky (1550 of 1959) is queried, and an analysis presented which leads to lower values of vehicle potential and electron temperature.

551.507.362.2:621.391.812 **487**

Unusual Propagation of Satellite Signals—E. M. Dewan. (PROC. IRE, vol. 47, p. 2020; November, 1959.) Gives example of signal strength maxima for Sputnik I.

551.507.362.2:621.391.812.63 **488**

High-Frequency Fading Observed on the 40 Mc/s Wave Radiation from Artificial Satellite 1957α—G. S. Kent. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 10–20; October, 1959.) This fading is attributed to irregularities in the F region of the ionosphere. The properties of these irregularities are examined and compared with those thought to be responsible for radio star scintillations and spread-F echoes.

551.507.362.2:621.396.41 **489**

Multiplexing Techniques for Satellite Applications—King. (See 664.)

551.508.822:551.594 **490**

Radiosondes for Measurements of Atmospheric Electricity—R. Mühleisen and H. J. Fischer. (*Arch. tech. Messen*, no. 274, pp. 229–

232; November, 1958.) Four types of radiosonde are described.

551.51+523.755 **491**

The Earth in the Sun's Atmosphere—S. Chapman. (*Sci. Amer.*, vol. 201, pp. 64–71; October, 1959.) The extent, nature and interrelation of the solar and terrestrial atmospheres are considered.

551.510.52:523.74 **492**

Solar Activity and the Altitude of the Tropopause near the Equator—D. Stranz. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 180–182; October, 1959.) The height of the tropopause at Leopoldville and the Zurich sunspot number are shown to be correlated during 1953–1958. The consequent possibility of a relation between solar activity and tropospheric conditions is discussed.

551.510.53 **493**

Molecular Oxygen Densities in the Mesosphere at Fort Churchill—J. E. Kupperian, Jr., E. T. Byram and H. Friedman. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 174–178; October, 1959.) Densities between 70 and 86 km were lower in early spring by a factor 1.8 than in midsummer. Dissociation appeared to begin near 96 km in March, 1958 and 86 km in July, 1957.

551.510.535 **494**

A Contribution to the Theory of the Motion of Weak Irregularities in the Ionosphere—P. C. Clemmow and M. A. Johnson. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 21–36; October, 1959.) If diffusion is neglected, any one-dimensional irregularity travels unchanged with a constant velocity which depends on the magnitude and direction of the ionospheric electrostatic and magnetostatic fields. In the same way, a weak two-dimensional irregularity which is parallel to the direction of the magnetostatic field travels with a constant velocity and preserves its shape; more complicated irregularities do not preserve their shape.

551.510.535 **495**

A Discussion of the Motion in Nitrogen of Free Electrons with Small Energies with Reference to the Ionosphere—L. G. H. Huxley. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 46–58; October, 1959.) It is found that the collision cross section of electrons is proportional to their velocity. From this result, an accurate expression is derived for the velocity of electron drift in terms of the mean energy of the electrons. The energy losses are found to be mainly due to excitation of the rotational states of the nitrogen molecules. With these results, measurements of radiowave interaction can be used to deduce molecular densities in the height range 82–90 km. These densities are consistent with the ARDC model atmosphere.

551.510.535 **496**

A Theory of Electrostatic Fields in a Horizontally Stratified Ionosphere Subject to a Vertical Magnetic Field —D. J. Farley, Jr. (*J. Geophys. Res.*, vol. 64, pp. 1225–1233; September, 1959.) A discussion of a possible explanation of spread-F and radiostar scintillation.

551.510.535 **497**

New Methods and Some Results Concerning True Ionospheric Height Calculations—W. Becker. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 67–83; October, 1959.) Three methods are described: a) an optical-graphical comparison method using given models, b) a general method applicable to monotonic $h'(f)$ traces, and c) a method which applies to the model method corrections which are derived from differences between the actual and model $h'(f)$ traces. It is shown how retardation in the E_s layer can be used to estimate the depth of the minimum between the E and F layers.

551.510.535 **498**

Transient Fine Structure of the E Layer—W. Dieminger. (*J. Atmos. Terr. Phys.*, vol. 16, p. 179; October, 1959.) A note on the fine structure of the E layer and its variability as observed using an ionosonde with high power and slow frequency variation.

551.510.535 **499**

The Ionospheric E Layer at Cape Hallett—G. A. M. King. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 186–187; October, 1959.) Ionograms were examined and the E-layer critical frequencies of those unaffected by ionization movements were compared with those expected on a simple Chapman model. Agreement was good when an electron recombination process was considered for the model.

551.510.535 **500**

The Gyro-Frequency in the E-layer above Slough, England—W. R. Piggott. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 197–198; October, 1959.) "Measurements of the gyro-frequency, f_H in the E layer from the separation of f_0E and f_zE at Slough give $f_H = 1.236 \pm 0.015$ mc. The calculated value is $f_H = 1.27$ mc. The difference is consistent with that found by Scott (2001 of 1951) using $f_0E - f_zE$ measured at high latitudes."

551.510.535 **501**

The Early-Morning E_2 Layer and some Evidence of Pre-Sunrise F-Layer "Splitting"—P. Bandyopadhyay. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 84–92; October, 1959.) Observations at Haringhata, India, show that E_2-layer cusps and ridges are regular sunrise phenomena at that location, with marked seasonal variations in character and frequency of occurrence. A "splitting" of the F layer during early morning in winter is also observed and the possible bearing of this on the E-layer phenomena observed is discussed.

551.510.535 **502**

Annual Distribution of Sporadic E—N. C. Gerson. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 189–191; October, 1959.) The geographical distribution of E_s ionization over North America during 1949 is studied from reports of VHF radio contacts.

551.510.535 **503**

Sporadic-E Ionization over Lindau/Harz during Last Year—W. Becker. (*Arch. elekt. Übertragung*, vol. 12, pp. 481–487; November, 1958.) Ionospheric sounding data obtained during the period August, 1957–July, 1958, are subjected to a detailed statistical analysis. More detailed investigations are proposed to ascertain the causes of E_s ionization.

551.510.535 **504**

Annual Wave in the World-Wide F-Region Ionization—B. N. Bhargava. (*Indian J. Meteorol. Geophys.*, vol. 10, pp. 69–72; January, 1959.) An analysis of the noon median value for f_0F_2 at 31 stations indicates that the annual component R_1 varies with latitude in a manner very similar to that of the steady ionization R_0. A similar analysis over a 9-year period for two of the stations gives a value of R_1 of the same order of magnitude as R_0, with a maximum around the epoch of minimum sun-earth distance.

551.510.535 **505**

Note on the Cause of Ionization in the F Region—M. H. Rees and W. A. Rense. (*J. Geophys. Res.*, vol. 64, pp. 1251–1255; September, 1959.) In view of the high absolute intensity of the solar 303.8-Å He II line recently observed by rocket at 140 km and 212 km, electron densities at these levels were computed assuming that the 303.8-Å photons ionize oxygen atoms. These computed densities approximate closely to those measured by rocket at these heights.

551.510.535 **506**

A New Theoretical Model of the Composite F Layer—F. Mariani. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 160–173; October, 1959.) It is suggested that bifurcation of the F layer is caused by a fairly rapid variation in temperature gradient and that tidal variations have only secondary effects. This model would explain the North-South asymmetry in electron density of the F_2 layer (see 3706 of 1959).

551.510.535 **507**

Single and Double Inflexions on the F-Trace—V. Marasigan. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 193–196; October, 1959.) An attempt is made to explain the bifurcation of the daytime F layer in terms of the Appleton-Lyon theory of the "height lag" (Appleton and Lyon, *Physics of the Ionosphere*, pp. 20–39; 1955). F-layer models are considered and, since the height lag decreases through the day, bifurcation takes place.

551.510.535 **508**

The Effect of the F_1 Layer on the Calculation of the Height of the F_2 Layer—M. D. Vickers. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 103–105; October, 1959.) "An approximate relationship between the estimated true height of the peak of the F_2 layer, and that given by assuming a single layer having a parabolic electron-density distribution, is derived and compared with experimental data."

551.510.535:523.78 **509**

Anomalous Ionospheric Reflection during Solar Eclipses—W. L. Price. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 93–98; October, 1959.) Analysis of electron densities during an eclipse shows that while the slope and curvature of layer strata are mostly very small, effective discontinuities can occur which would produce complexities in ionograms These complexities are due to rays reflected along paths inclined to the vertical.

551.510.535:523.78 **510**

Ionospheric Observations on the F Region during the Solar Eclipse of 19 April 1958—S. Datta, P. Bandyopadhyay and R. N. Datta. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 182–185; October, 1959.) Results obtained at Haringhata, India, demonstrate eclipse effects in the F_2 layer for maximum electron density, total electron content of a unit column and true height of the layer peak.

551.510.535:539.16 **511**

On Artificial Geomagnetic and Ionospheric Storms associated with High-Altitude Explosions—S. Matsushita. (*J. Geophys. Res.*, vol. 64, pp. 1149–1161; September, 1959.) Associated with the nuclear explosions at Johnston Island on August 1 and 12, 1958, were a) circular electric currents, explicable on the hypothesis of the dynamo effect, which caused observed magnetic variations at places up to 2200 km distant, b) fast particles traveling along magnetic lines of force and causing aurora and magnetic storms at Apia, c) X rays which increased D-region ionization by about eight times at Maui.

551.510.535:551.507.362.2 **512**

The Electron Density in the Outer Ionosphere—L. Klinker, R. Knuth and K. H. Schmelovsky. (*Z. Meteorol.*, vol. 13, pp. 192–193; July/August, 1959.) Faraday fading records at Kühlungsborn (East Germany) of 20- and 40-mc transmissions from satellite 1958δ2 during daytime transits in summer

1958 were used to derive the mean-electron-density profile. The electron density falls from about 0.7×10^{12} meter^{-3} at 380 km to half this value at about 660 km, and to 0.15×10^{12} meter^{-3} at a height of 1200 km.

551.510.535:621.391.812.63 513

Sudden Changes in the Virtual Height of Radio Waves Reflected from the *E* Region of the Ionosphere—J. D. Whitehead. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 99–102; October, 1959.) It is shown that the lower-level reflections are from thin layers within the normal *E* region. The changes in amplitude are used to deduce the thickness of these layers and the electronic collision frequency in the *E* region.

551.510.535:621.391.812.63:523.75 514

The Interpretation of Sudden Field Anomalies in the Long-Wave Range during Solar Flare Effects—Lauter and Třiska. (See 648.)

551.510.535(98) 515

The Height of *F*-Layer Irregularities in the Arctic Ionosphere—H. F. Bates. (*J. Geophys. Res.*, vol. 64, pp. 1257–1265; September, 1959.) Frequency-sweep back scatter soundings from College, Alaska, show that *F*-layer irregularities exist at heights of 350–500 km, and sometimes extend 1500 km in a north-south direction.

551.510.535(99) 516

Observations of the Ionosphere over the South Geographic Pole—R. W. Knecht. (*J. Geophys. Res.*, vol. 64, pp. 1243–1250; September, 1959.) "It is found that *F*-region ionization persists throughout the 6-month winter night. Marked diurnal variations are observed in the monthly medians of f_0F_2 even though the usual daily variation in solar elevation is absent at this unique location. A small but significant diurnal variation is also found in f_0F_1. In contrast, f_0E exhibits no regular daily fluctuation, but seems to depend to a greater extent on the level of solar activity."

551.510.536:550.38 517

Motions in the Magnetosphere of the Earth—T. Gold. (*J. Geophys. Res.*, vol. 64, pp. 1219–1224; September, 1959.) The magnetosphere is defined as the region above the ionosphere in which the earth's magnetic field has dominant control over the motions of gas and fast charged particles. Conditions in the magnetosphere and the dynamical behavior of its constituents are discussed.

551.594.5 518

Horizontal Movements of Visual Auroral Features—S. Evans. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 191–193; October, 1959.) Measurements with all-sky cameras show that, for Halley Bay during July and August, 1956, auroral movements were predominantly east-west with a reversal in direction from west to east at 0300 UT.

551.594.5 519

Existence of an Inner Auroral Zone—K. Lassen. (*Nature*, vol. 184, suppl. no. 18, pp. 1375–1377; October 31, 1959.) Study of a "population" of auroras which seems to form an inner auroral zone.

551.594.5 520

Type-*B* Aurora in the Antarctic—J. M. Malville. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 59–66; October, 1959.) The results of auroral observations are discussed and an excitation mechanism is suggested to explain the type-*B* spectrum.

551.594.5:621.396.96 521

VHF and UHF Radar Observations of the Aurora at College, Alaska—R. I. Presnell, R. L. Leadabrand, A. M. Peterson, R. B. Dyce, J. C. Schlobohm and M. R. Berg. (*J. Geophys. Res.*, vol. 64, pp. 1179–1190; September, 1959.) Within the frequency interval 200–800 mc, radar echoes show that the aurora conforms to the Booker model (2739 of 1956), provided that the longitudinal correlation length is halved and the transverse correlation distance is reduced from 0.16 meter to 0.1 meter. A daytime "diffuse" aurora is found to exist in the *E* layer, almost parallel to the earth's surface, and is under strong solar control.

551.594.5:621.396.96 522

High-Altitude 106.1-mcs Radio Echoes from Auroral Ionization Detected at a Geomagnetic Latitude of 43°—J. C. Schlobohm, R. L. Leadabrand, R. B. Dyce, L. T. Dolphin and M. R. Berg. (*J. Geophys. Res.*, vol. 64, pp. 1191–1196; September, 1959.)

551.594.5:621.396.96 523

Doppler Investigations of the Radar Aurora at 400 Mc/s—R. L. Leadabrand, R. I. Presnell, M. R. Berg and R. B. Dyce. (*J. Geophys. Res.*, vol. 64, pp. 1197–1203; September, 1959.)

551.594.6 524

Directional Observations of Radio Noise from the Outer Atmosphere—G. R. A. Ellis and D. G. Cartwright. (*Nature*, vol. 184, suppl. no. 17, pp. 1307–1308; October 24, 1959.) Report of preliminary results obtained with a direction finder operated at a wave-frequency of 4.5 kc.

551.594.6 525

Spaced Observations of Radio Noise from the Outer Atmosphere—G. R. A. Ellis, D. G. Cartwright and J. R. V. Groves. (*Nature*, vol. 184, suppl. no. 18, pp. 1391–1392; October 31, 1959.) Observations made at two stations 1000 km apart show that the regions in which the noise is generated are normally stationary with respect to the earth.

551.594.6 526

Location of Initial Sferics of Long Whistlers—G. Entzian and C. Popp. (*Z. Meteorol.*, vol. 13, pp. 193–194; July/August, 1959.) Sources of atmospherics were located by a U.S.S.R. research vessel in the vicinity of Ireland in December, 1958, and coincidences with long whistlers were observed. One of the records is analyzed.

551.594.6:551.510.535 527

Synthesis of the Waveforms of Atmospherics and Effective Parameters of the Lower Ionosphere at Low Frequencies—Ya. L. Al'pert and D. S. Fligel'. (*Radiotekh. Elektron.*, vol. 4, pp. 202–211; February, 1959.) Theoretical estimations of the waveforms of atmospherics are compared with signals received over a distance of 500–3000 km. Results are tabulated for the frequency range 5–10^5 cps.

LOCATION AND AIDS TO NAVIGATION

621.396.9:656.052:061.3 528

Automatic Methods of Navigation—(*J. Inst. Nav.*, vol. 12, pp. 318–333; July–October, 1959.) A list is given, with summaries, of papers presented at the Convention held in Paris, April 28–29, 1959.

621.396.932.2:523.164.3 529

Automatic Radio-Celestial Navigation—G. R. Marner. (*J. Inst. Nav.*, vol. 12, pp. 249–259; July–October, 1959.) A general discussion of the problems associated with radiocelestial navigation and of the optimum frequency for a practical system using the sun and moon as radiation sources.

621.396.933.1 530

Air and Sea Tests of the Dectra Radio-Navigation System—C. Powell. (*J. Inst. Nav.*, vol. 12, pp. 289–307; July–October, 1959.) A summary of the results obtained during the first two years' operation of the experimental Dectra chain in the North Atlantic area. Reference is made to observations at fixed monitor stations and to the data link for air-to-ground transmission of the Dectra fix.

621.396.96:621.391.812.624 531

Subhorizon Radar Echoes by Scatter Propagation—Atlas. (See 640.)

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215:535.37 532

Calculation of the Photoconductivity from A.C. Impedance Changes Induced in ZnS and ZnCdS Phosphors—H. Kallmann, B. Kramer and P. Mark. (*J. Phys. Chem. Solids*, vol. 10, pp. 59–63; April, 1959.) Equations are derived from which the photoconductivity and conduction-band electron density can be obtained from the ac measurements. The theoretical and experimental results for five phosphors are compared.

535.215:537.311.33 533

Optical Sensitization in the Photoelectric Effect at the Contact between a Semiconductor and an Organic Dye—E. K. Putseiko. (*Dokl. Akad. Nauk SSSR*, vol. 129, pp. 303–306; November 11, 1959.) This effect can be obtained by absorption of the dye from a solution or by pressing the solid layers of the dye powder against the ZnO semiconductor. Results indicate that the maximum photo-emf at the junction of dye and ZnO is of several millivolts per milliwatt.

535.215:546.48'221 534

Edge Photoconductivity of Cadmium Sulphide—M. Avinor. (*Philips Res. Rept.*, vol. 14, pp. 211–214; June, 1959.) It is shown that the characteristic photoconductivity peak of single crystals of CdS at 515 mμ is not due to band-band transition.

535.215:546.48'221 535

Induced Conductivity of CdS by β- and γ-rays—S. Ibuki. (*J. Phys. Soc. Japan*, vol. 14, pp. 1196–1204; September, 1959.) Experimental study, and comparison with effects produced by visible light.

535.215:546.492'151 536

The Influence of the Contacts on the Photoconductivity of Red Mercury Iodide—E. Batt and F. Stöckmann. (*Z. Naturforsch.*, vol. 13a, pp. 352–354; April, 1958.) Discrepancies between the I/V characteristics reported by different authors (*e.g.*, R. H. Bube, *Phys. Rev.*, vol. 106, pp. 703–717; May 15, 1957) are shown, by measurements, to be due to the effect of different contact materials.

535.37 537

A Theory of Edge-Emission Phenomena in CdS, ZnS and ZnO—J. J. Hopfield. (*J. Phys. Chem. Solids*, vol. 10, pp. 110–119; July, 1959.) Based on a tight-binding model, band symmetries and splittings which reproduce the currently known polarization phenomena in absorption and edge emission are given. Experimental observations are compared with predictions based on this model.

535.37:546.48'221 538

Edge and Impurity Emission in Cadmium Sulphide—D. Warschauer and D. C. Reynolds. (*Phys. Rev. Lett.*, vol. 3, pp. 370–372; October 15, 1959.) Some observations are given which cannot be explained in terms of the simple model recently proposed [*e.g.*, 2268 of 1959 (Birman)].

535.37:546.48'221:548.5 539

On the Crystal Growth of Cadmium Sulphide—S. Ibuki. (*J. Phys. Soc. Japan*, vol. 14, pp. 1181–1195; September, 1959.) A study of crystal growth by sublimation and recrystallization, and the conditions under which various kinds of crystal are formed.

535.376 540

The Phasing of Luminescence-Wave Secondary Maxima of Electroluminescence—D. Hahn and F. W. Seemann. (*Z. Naturforsch.*, vol. 13a, pp. 349–350; April, 1958.) The temperature dependence of the phase of secondary waves with sinusoidal excitation is investigated. The apparently large phase shift may be due to an incorrect interpretation of measurements. See also 833 of 1959.

535.376 541

Long-Period Afterglow of KCl:Tl Phosphor under Cathode-Ray Excitation—V. V. Ratnam. (*Proc. Nat. Inst. Sci. India*, Part A, vol. 25, pp. 111–117; March 26, 1959.) KCl:Tl phosphor was excited by 11-kv cathode rays and the decay of the afterglow studied over the temperature range of 150–400°K. Results indicate that the value of s, the frequency factor, is not the same for all trapping centers.

535.376:546.47'221 542

Electroluminescence of ZnS Phosphors Excited by Short Field Pulses—S. Tanaka. (*J. Phys. Soc. Japan*, vol. 14, pp. 1123–1140; September, 1959.) Experimental studies of emission spectra, brightness waveforms, decay times, and dependence of light output on applied voltages are described. The results are discussed in relation to the mechanisms involved and the corresponding effects with sinusoidal field excitation.

537.226 543

Dielectric Research—(*Tech. News Bull. Nat. Bur. Stand.*, vol. 43, pp. 168–174; September, 1959.) A report of studies of a wide range of dielectric materials.

537.227 544

Built-In Nucleation Sites in Triglycine Sulphate—A. G. Chynoweth and J. L. Abel. (*J. Appl. Phys.*, vol. 30, pp. 1615–1617; October, 1959.) Sites for domain nucleation at low fields are mainly determined by gross singularities or conditions built in as the crystal grows.

537.227:546.431'824–31 545

Ferroelectric After-Effects in Polycrystalline Barium Titanate—W. Koch. (*Z. Naturforsch.*, vol. 13a, pp. 303–310; April, 1958.) The anomalous variation of dielectric constant when an electric field is applied to $BaTiO_3$ specimens or when the specimens are subjected to hydrostatic pressure is investigated. Results are interpreted in terms of the splitting up of domains and the shifting of the tetragonal-to-orthorhombic transition temperature.

537.227:546.431'824–31:537.311.33 546

Properties of Semiconductive Barium Titanates—O. Saburi. (*J. Phys. Soc. Japan*, vol. 14, pp. 1159–1174; September, 1959.) The reduction of the resistivity of barium titanate by various additives is investigated, and mechanisms for the effect are discussed.

537.227:546.431'824–31:538.569.4 547

Electron Paramagnetic Resonance in Single Crystals of $BaTiO_3$—A. W. Hornig, R. C. Rempel and H. E. Weaver. (*J. Phys. Chem. Solids*, vol. 10, pp. 1–11; April, 1959.) The resonance spectrum is due to the impurity ion Fe^{3+}, believed to be located at the titanium position in the unit cell.

537.227:546.431'824–31:539.12.04 548

Radiation-Induced Changes in the Ferroelectric Properties of some Barium-Titanate-Type Materials—I. Lefkowitz. (*J. Phys. Chem. Solids*, vol. 10, pp. 169–173; July, 1959.) Measurements on pure ceramic $BaTiO_3$ showed a depression of the dielectric constant peak with little modification of the room temperature dielectric constant. Ceramics made with additives showed a shift of the Curie point as well as a depression of the dielectric constant peak. Materials exposed to an integrated pile dosage of $1\times10^{18}nvt$ would not support reversible dielectric polarization.

537.311.31:539.23:537.228 549

Surface States in Metals—G. Bonfiglioli and R. Malvano. (*Phys. Rev.*, vol. 115, pp. 330–335; July 15, 1959.) Conductivity modulation by an electric field has been measured in Au, Sb and Bi films using a new technique. The existence of localized and conducting "surface states" at the metal/dielectric interface seems to be experimentally confirmed.

537.311.31:621.317.321 550

The Contact Potential on Metal Surfaces with Oxidation and with Adsorption—W. Schaaffs. (*Z. angew. Phys.*, vol. 10, pp. 503–511; November, 1958.) For the method of measurement used, see 225 of January (Schaaffs and Woelk).

537.311.33 551

Organic Semiconductors—D. D. Eley. [*Research* (*London*), vol. 12, pp. 293–299; August/September, 1959.] Results of measurements of electrical conductivity of crystalline organic substances are reviewed. Conductivity may be associated with the intermolecular tunneling of thermally excited π-electrons. 54 references.

537.311.33 552

Theory and Application of a Minority Carrier Sweep-Out Effect—R. D. Larrabee. (*J. Appl. Phys.*, vol. 30, pp. 1535–1538; October, 1959.) A simplified analysis shows how the effect may be used to determine the density and drift mobility of carriers of both signs.

537.311.33 553

Determination of Avalanche Breakdown in *p-n* Junctions—J. Maserjian. (*J. Appl. Phys.*, vol. 30, pp. 1613–1614; October, 1959.) A single effective value of the ionization rate per cm for both holes and electrons may be used in the approximate analysis presented. See also 2453 of 1958 (Chynoweth).

537.311.33:537.32 554

On the Theory of Thermoelectricity—J. Tauc. (*J. Phys. Soc. Japan*, vol. 14, pp. 1174–1175; September, 1959.) Discussion of the electric field inside a two-band semiconductor with temperature-dependent energy gap. See 3015 of 1959 (Haga).

537.311.33:537.32:538.63 555

Theory of Thermomagnetic Effects of Nonpolar Isotropic Semiconductors—J. Appel. (*Z. Naturforsch.*, vol. 13a, pp. 386–402; May, 1958.) Changes of transverse thermoelectric power, thermal conductivity and Nernst-Ettingshausen coefficient are calculated as a function of temperature and magnetic field strength. Good agreement with theory can be obtained for the results of measurements on pure p-type Ge at 80°K. See also 3511 of 1957 (Parrott).

537.311.33:546.26–1 556

Hall Coefficient and Magnetoresistance in Semiconducting Diamond—R. T. Bate and R. K. Willardson. (*Proc. Phys. Soc.*, vol. 74, pp. 363–367; September 1, 1959.) The Hall coefficient was found to increase monotonically with increasing magnetic field H, while the transverse magnetoresistance was proportional to H^2 at low-field strengths.

537.311.33:546.28 557

A Volume Effect in the Etching of Silicon Single Crystals—H. Benda. (*Z. Naturforsch.*, vol. 13a, pp. 354–355; April, 1958.) The effect observed may be due to the diffusion of hydrogen into the silicon.

537.311.33:546.28 558

Birefringence due to Residual Stress in Silicon—J. Hornstra and P. Penning. (*Philips Res. Repts.*, vol. 14, pp. 237–249; June, 1959.)

537.311.33:546.28 559

Cleaning of Silicon Surfaces by Heating in High Vacuum—F. G. Allen, J. Eisinger, H. D. Hagstrum and J. T. Law. (*J. Appl. Phys.*, vol. 30, pp. 1563–1571; October, 1959.) Heating at 1550°K for several minutes forms permanent p-type layers several microns deep with atomically clean surfaces.

537.311.33:546.28 560

Influence of the Ambient Atmosphere on the Surface Recombination of Silicon—H. U. Harten. (*Philips Res. Repts.*, vol. 14, pp. 207–210; June, 1959.) Measurements of the surface photovoltage show that the surface potential of Si can be altered over a wide range by chemical surface treatments and over a smaller range by the ambient atmosphere. An investigation of the surface recombination shows this process to be determined chiefly by recombination centers of the "Hall-Shockley-Read-type."

537.311.33:546.289 561

Pressure-Dependence of the Resistivity of Germanium—A. Michels, J. Van Eck, S. Machlup and C. A. Ten Seldam. (*J. Phys. Solids*, vol. 10, pp. 12–18; April, 1959.) "The effect of hydrostatic pressure on the resistance of a p-type sample of germanium (specific resistivity about 80 Ω-cm at 293°K) has been investigated up to 2700 atm. at temperatures between 125 and −150°C. The results in the intrinsic range indicate an increase in the energy gap of 5.4×10^{-6} ev/atm, in agreement with earlier experimental determinations. In the extrinsic region, the resistivity decreases slightly with pressure, indicating an increase in hole mobility of 9 ppm/atm."

537.311.33:546.289 562

The Thermal Conductivity of Germanium at High Temperatures—F. Kettel. (*J. Phys. Chem. Solids*, vol. 10, pp. 52–58; April, 1959. In German.)

537.311.33:546.289 563

Recombination Properties of Nickel in Germanium—G. K. Wertheim. (*Phys. Rev.*, vol. 115, pp. 33–47; July 1, 1959.) Experimental lifetime data agree with known energy levels and solid solubility. Three electron-capture cross sections associated with the three charge states assigned to Ni have been determined.

537.311.33:546.289 564

Thermal Oscillations in *n*-Germanium at Low Temperature—S. H. Koenig and R. D. Brown, III. (*J. Phys. Chem. Solids*, vol. 10, pp. 201–203; July, 1959.) Instability occurs when a small increase in current in part of the sample produces a local temperature rise which cannot be dissipated before it in turn causes a further current increase. The oscillations cause an effective negative resistance to appear when dc measurements are made in the usual manner.

537.311.33:546.289 565

Recombination Relaxation Effects in Germanium Surfaces—D. H. Lindley and P. C. Banbury. (*Proc. Phys. Soc.*, vol. 74, pp. 395–400; October 1, 1959.) A small electric field of variable frequency was used to modulate the conductance of a thin crystal slab. The resulting dispersion has been studied and the relsuts are in agreement with Garrett's model (153 of

1958) and give recombination data in agreement with those obtained by other methods.

537.311.33:546.289 566

Dislocation Pinning in *n*-Type Germanium—R. L. Cummerow and A. R. Cherry. (*Phys. Rev. Lett.*, vol. 3, pp. 367–368; October 15, 1959.) A thermally-induced-glide technique was used on samples of *p*-type Ge doped with Ga and *n*-type Ge doped with As. A glide was observed on the *p*-type but none was present on the *n*-type until a temperature of 700°C was reached. An explanation of this pinning by the As impurities is given.

537.311.33:546.289:535.215–15 567

Emission and Absorption of Long-Wave Infrared Radiation by Germanium in the Photoconducting State—F. R. Kessler. (*Z. Naturforsch.*, vol. 13a, pp. 295–302; April, 1958.) The absorption spectrum of electron-hole pairs in the range 3–15 microns was determined in Ge at temperatures between 20 and 70°C. A maximum of infrared emission was found at a wavelength of 10 microns; this was investigated for various temperatures and as a function of the number of electron-hole pairs. A phenomenological interpretation of the effects is given.

537.311.33:546.289:537.312.9 568

Piezoresistance of *n*-Type Germanium—H. Fritzsche. (*Phys. Rev.*, vol. 115, pp. 336–345; July 15, 1959.) A study at low temperatures of the departure of the piezoresistance from linear dependence on applied stress and a test of the predictions of the electron transfer model at large stresses. Results indicate that the model is a useful one.

537.311.33:546.289:548.73 569

X-Ray Representation of the Dislocation Field of Individual Dislocations in Germanium Single Crystals—U. Bonse and E. Kappler. (*Z. Naturforsch.*, vol. 13a, pp. 348–349; April, 1958; plate.)

537.311.33:546.3–87'86 570

Semiconducting Properties of Bi-Sb Alloys—S. Tanuma. (*J. Phys. Soc. Japan*, vol. 14, p. 1246; September, 1959.) Measurements of resistivity, Hall effect and magnetoresistance of polycrystalline specimens, in the temperature range 4.2°K to 300°K.

537.311.33:546.36'59 571

Studies of the Semiconducting Properties of the Compound CsAu—W. E. Spicer, A. H. Sommer and J. G. White. (*Phys. Rev.*, vol. 115, pp. 57–62; July 1, 1959.) Experimental results are given and discussed.

537.311.33:546.47–31:535.34–15 572

Infrared Absorption in Zinc Oxide Crystals—D. G. Thomas. (*J. Phys. Chem. Solids*, vol. 10, pp. 47–51; April, 1959.) Absorption in the 1- to 12-micron band is shown to be due to free carriers, lattice vibration bands and photoionization of impurities.

537.311.33:546.48'19 573

Cd_3As_2—a Noncubic Semiconductor with Unusually High Electron Mobility—A. J. Rosenberg and T. C. Harman. (*J. Appl. Phys.*, vol. 30, pp. 1621–1622; October, 1959.) At a carrier concentration of $4\times10^{18}/cm^3$ the mobility at 300°K is 10,000, the highest reported for any material.

537.311.33:546.561–31 574

The Semiconductor Properties of Cu_2O—K. Stecker. (*Ann. Phys.* (*Lpz.*), vol. 3, pp. 55–81; February 28, 1959.)

Part 12: The Conductivity of Cu_2O within the Existence Limits at High Temperatures in the Range of Low Pressures (pp. 55–69).

Part 13: Conductivity Measurements on Cu_2O within the Existence Limits with a Disturbance of the Thermodynamic Equilibrium (pp. 70–81).

Part 11: 3595 of 1954 (Blankenburg).

537.311.33:546.68'19 575

Thermal Electrical and Optical Properties of (In,Ga)As Alloys—M. S. Abrahams, R. Braunstein and F. D. Rosi. (*J. Phys. Chem. Solids*, vol. 10, pp. 204–210; July, 1959.)

537.311.33:546.628'86 576

Recombination Processes in *p*-Type Indium Antimonide—R. N. Zitter, A. J. Strauss and A. E. Attard. (*Phys. Rev.*, vol. 115, pp. 266–273; July 15, 1959.) Photoelectromagnetic and photoconductive lifetimes have been measured from 77° to 300°K in monocrystalline *p*-type InSb of net acceptor concentration ranging from less than 10^{15} cm^{-3} to $10^{18} cm^{-3}$. Experimental procedures and results are discussed.

537.311.33:546.682'86 577

Electron Damage Thresholds in InSb—F. H. Eisen and P. W. Bickel. (*Phys. Rev.*, vol. 115, pp. 345–346; July 15, 1959.) Measurements indicate that displacements are produced at electron energies as low as 240 kev.

537.311.33:546.873'241 578

Bismuth Telluride and Related Compounds—D. A. Wright. [*Research* (*London*), vol. 12, pp. 300–306; August/September, 1959.] The structure and physical properties are reviewed and reference is made to thermoelectric applications.

537.311.33:548.73 579

Shadows of Dislocation Lines in X-Ray Diagrams—G. Borrmann, W. Hartwig and H. Irmler. (*Z. Naturforsch.*, vol. 13a, pp. 423–425; May, 1958.) Diagrams obtained with a Si disk are shown and discussed.

537.32 580

Materials for Thermoelectric Refrigeration—F. D. Rosi, B. Abeles and R. V. Jensen. (*J. Phys. Chem. Solids*, vol. 10, pp. 191–200; July, 1959.) Thermoelectric propreties of Bi_2Te_3 and alloys with Sb and Se were measured.

537.32 581

Theory of Thermoelectric Power of Ionic Crystals: Part 3—E. Haga. (*J. Phys. Soc. Japan*, vol. 14, pp. 1176–1181; September, 1959.) The variation with time is calculated of the thermoelectric power in a AgCl crystal doped with CuCl for prescribed conditions of temperature gradient in the crystal.

537.583 582

Characteristics of UC,ZrC and (ZrC)(UC) as Thermionic Emitters—R. W. Pidd, G. M. Grover, D. J. Roehling, E. W. Salmi, J. D. Farr, N. H. Krikorian and W. G. Witteman. (*J. Appl. Phys.*, vol. 30, pp. 1575–1578; October, 1959.) Excellent emission properties are reported.

538:061.3 583

Magnetism and Magnetic Materials—(*J. Appl. Phys.*, vol. 30, suppl., pp. 1S–323S; April, 1959.) The text is given of papers presented at a conference held in Philadelphia, Pa., November 17–20, 1958.

538.22:538.569.4 584

Structure-Sensitivity of the High-Frequency NMR in Powdered Antiferromagnetic MnF_2—J. L. Davis, G. E. Devlin, V. Jaccarino and A. L. Schawlow. (*J. Phys. Chem. Solids*, vol. 10, pp. 106–109; July, 1959.)

538.22:538.569.4 585

Electron Spin Resonance of Gd^{3+} in Lanthanum Fluoride—D. A. Jones, J. M. Baker and D. F. D. Pope. (*Proc. Phys. Soc.*, vol. 74, pp. 249–256; September, 1959.) The large crystal-field splitting observed in a single-crystal of LaF_3 containing 0.01 per cent Gd^{3+}, which is about 0.3 cm^{-1} in zero magnetic field, indicates a possible application of the salt as a maser material.

538.221:539.23 586

Curie Point in Thin Ni Films determined by Electrical Method—K. Kuwahara. (*J. Phys. Soc. Japan*, vol. 14, p. 1246; September, 1959.) Determinations of Curie temperature, using the anomalies in resistance and magnetoresistance which occur at that point.

538.221:621.318.124 587

Magnetic Materials with Perminvar Effect: Part 4—Perminvar and Magnetic-Field Annealing Effect in connection with the After-Effect in Ferrites due to Electron Diffusion—A. v. Kienlin. (*Z. angew. Phys.*, vol. 10, pp. 562–565; December, 1958.) **Part 3**: 2324 of 1959.

538.221:621.318.134 588

Low-Temperature Heat Capacities and Thermodynamic Properties of Zinc Ferrites: Part 3—E. F. Westrum, Jr. and D. M. Grimes. (*J. Phys. Chem. Solids*, vol. 10, pp. 120–125; July, 1959.)

Part 1—3178 of 1958.

Part 2—*J. Phys. Chem. Solids*, vol. 6, pp. 280–286; August, 1958.

538.221:621.318.134 589

The Ferrimagnetism and Crystal Chemistry of Substituted Manganese-Tin Spinels—M. A, Gilleo and D. W. Mitchell. (*J. Phys. Chem. Solids*, vol. 10, pp. 182–186; July, 1959.)

538.221:621.318.134 590

The Interaction of Magnetic Ions in $Gd_3Mn_2Ge_2GaO_{12}$ and Related Garnets—M. A. Gilleo and S. Geller. (*J. Phys. Chem. Solids*, vol. 10, pp. 187–190; July, 1959.)

538.221:621.318.134 591

Proposed Means for Realizing High Power Stability in Magnetic Oxides—L. G. Van Uitert, R. C. LeCraw, E. G. Spencer and R. L. Martin. (*J. Appl. Phys.*, vol. 30, pp. 1623–1624; October, 1959.) The stability is proportioned to the line width (ΔHk) of the spin wave that first goes unstable as the RF power is increased; possible means of increasing ΔHk are suggested.

538.222:538.569.4 592

Quadrupole Selection Rule in Iron-Group Spin-Phonon Interactions—R. D. Mattuck and M. W. P. Strandberg. (*Phys. Rev. Lett.*, vol. 3, pp. 369–370; October 15, 1959.)

539.2:539.12.04 593

Mechanical Properties of Irradiated Solids—F. A. Levi. (*Nuovo Cim.*, vol. 12, suppl. no. 2, pp. 123–295; 1959.) Review of literature dealing with radiation effects in solids. 693 references.

621.315.6:537.311 594

Two-Carrier Space-Charge-Limited Current in a Trap-Free Insulator—R. H. Parmenter and W. Ruppel. (*J. Appl. Phys.*, vol. 30, pp. 1548–1558; October, 1959.)

621.318.132:621.375.3.042.143 595

Core Materials and Core Designs for Magnetic Amplifiers—H. Faehse. (*VDI Zeitschrift*, vol. 101, pp. 341–342; March 21, 1959.) Review of modern lamination materials, particularly of those with grain orientation, including an outline of design features required for full exploitation of magnetic properties.

MATHEMATICS

512:621.316.5 596
Algebraic Topological Methods for Contact Network Analysis and Synthesis—C. Saltzer. (*Quart. Appl. Math.*, vol. 17, pp. 173–183; July, 1959.)

512:621.318.57:681.142 597
Classification and Minimization of Switching Functions: Part 2—N. C. de Troye. (*Philips Res. Repts.*, vol. 14, pp. 250–292; June, 1959.) **Part 1**—3048 of 1959.

517 598
A Note on Addition Theorems for Mathieu Functions—K. Saermark. (*Z. angew. Math. u Phys.*, vol. 10, pp. 426–428; July 25, 1959. In English.) Note on an addition theorem differing from that given by Meixner and Schäfke (511 of 1956).

MEASUREMENTS AND TEST GEAR

529.786+531.71](083.7) 599
Atomic Standards of Length and Time—H. Barrell and L. Essen. (*Sci. Progr.*, vol. 47, pp. 209–229; April, 1959.) The development of sources of monochromatic light and atomic beams is reviewed, and the design and application of spectral-line frequency standards are described. 31 references.

621.3.018.41(083.74) 600
Using Low-Frequency Standard Broadcasts—H. F. Burgess and M. C. Jones. (*Electronics*, vol. 32, pp. 48–49; October 30, 1959) A technique is outlined for the calibration of 100-kc oscillators, from signals of the NBS 60-kc standard-frequency transmission (Station KK2XEI). The output of a coherent detector gives a continuous record of error, and the use of a narrow bandwidth permits operation at low input signal levels. Errors can be reduced to the order of 5 parts in 10^{10}.

621.317.3:621.382.2 601
The Measurement of Semiconductor Diode Switching Characteristics—J. N. Barry and S. F. Fisher. (*Brit. Commun. Electronics*, vol. 6, pp. 788–791; November, 1959.) Equipment for measuring the transient reverse current which flows when the applied voltage is switched from forward to reverse.

621.317.331.087.6:537.311.33 602
Improved Automatic Four-Point Resistivity Probe—D. Dew-Hughes, A. H. Jones and G. E. Brock. (*Rev. Sci. Instr.*, vol. 30, pp. 920–922; October, 1959.) Apparatus is described which automatically measures and plots the resistivity at fixed intervals along a semiconductor sample. The probe point spacing is 0.025 inch.

621.317.335+621.317.41.029.64:621.318.134 603
Apparatus for the Measurement of Tensor Permeability and Dielectric Properties of Ferrites at *X*-Band Frequencies—W. S. Carter. (*Marconi Rev.*, vol. 22, pp. 154–163; 3rd Quarter, 1959.) Equipment is described for measuring dielectric constant and loss on a routine basis. Measurements of permeability are also possible on representative samples.

621.317.337:621.372.413 604
The Measurement of the *Q*-Factor of Cavity Resonators Coupled to Transmission Lines, using a Measurement Line—H. W. Urbarz. (*Nachrichtentech. Z.*, vol. 11, pp. 571–576; November, 1958.) Expansion of the method of measurement given in 3141 of 1956.

621.317.4 605
Magnetic Measurements—K. J. Choudhury and P. C. Sen. (*Electronic Radio Eng.*, vol. 36, pp. 422–426; November, 1959.) A description is given of a modified bridged-T network for the measurement of incremental magnetic loss and ac permeability of cores subjected to superposed direct and alternating flux. Theoretical equations are presented for use over the frequency range 50 cps–50 kc.

621.317.4:538.632 606
Multiple-Element Hall-Effect Sensor—M. Epstein, H. M. Sachs and J. L. Greenstein. (Proc. IRE, vol. 47, p. 2014; November, 1959.) A design suiatble for magnetic-field measurements.

621.317.444:550.380.8 607
Some Remarks on the Proton Magnetometer—G. Klose. (*Z. angew. Phys.*, vol. 10, pp. 495–497; November, 1958.) The principle of operation of the magnetometer [see, *e.g.*, 526 of 1957 (Cahill and Van Allen)] and the accuracy of the measurement of the earth's magnetic field are discussed.

621.317.74:621.372.8 608
Recording Attenuation of Waveguide Components—G. Edelcreek. (*Electronics*, vol. 32, p. 126; October 23, 1959.) Description of a frequency-sweep method for measuring attenuation up to 80 db, with photographic recording of the CRO trace.

621.317.742 609
Unconventional Technique for Measuring VSWR—J. Hanson. (*Electronics*, vol. 32, pp. 120–121; October 23, 1959.) A transistorized instrument comprising an oscillator, a RC directional coupler and a meter indicator is described for measurements in the range 150–175 mc.

621.317.75 610
An Amplitude Distribution Meter—M. Drayson. (*Electronic Engrg.*, vol. 31, pp. 578–584; October, 1959.) The significance of signal amplitude distribution measurements is described, with a brief outline of the mathematical expressions and approximations involved in any practical system. The system described uses a specially developed CRT as the waveform sampler and has a resolution of 1 per cent in the band 0.1 cps–10 mc over a 0.3–30-volt amplitude range.

621.317.75:621.395.625.3 611
The Influence of Recording-Head and Tape Properties on the Recording of Magnetic-Tape Oscillograms—W. Reinert. (*Elektronik*, vol. 7, pp. 329–335; November, 1958.) Design problems of the magnetic-tape oscillograph (2187 of 1958) are discussed. A four-track recording head is described with illustrations of oscillograms produced by it and by a light-beam oscillograph for comparison.

621.317.755.087.6 612
New Method for Graphical Reproduction of Cathode-Ray Oscillograms—R. K. Swank and E. A. Mroz. (*Rev. Sci. Instr.*, vol. 30, pp. 880–884; October, 1959.) Description of an automatic optical-electronic device using two photomultipliers in a null system to reproduce graphically to high accuracy a repetitive CRO trace.

621.317.772.029.64:621.396.65 613
Experimental Equipment for Measuring Group Delay in the Frequency Band 3.8–4.2 Gc/s—R. J. Turner. (*P.O. Elec. Engrg. J.*, vol. 52, Part 53, pp. 207–211; October, 1959.) Measures group delay to within ±0.2 mμsec in 50 mμsec by determining the phase shift of a 1-mc modulating signal (low-deviation FM). A balanced phase comparator using thermionic diodes with adjustable heater voltages permits phase determination at 1 mc to within $\pm 0.07^{c}$.

621.317.79:681.142:621.385.833 614
An Electon-Trajectory Tracer for use with the Resistance Network Analogue—M. E. Haine. (*Proc. IRE*, Part B, vol. 106, pp. 517–525; November, 1959. Discussion, pp. 525–527.) "The paper describes an instrument for direct analog computation of electron trajectories, a resistance network providing the necessary field data. Constructional details are given and results for two typical electrostatic lenses are shown and compared with results obtained experimentally. Methods for improving accuracy and speed of operation are outlined."

621.317.794 615
The Inherent Sensitivity of Metal Bolometers—G. Barth. (*Optik*, vol. 15, pp. 694–709; November, 1958.) The maximum sensitivity of a bolometer is calculated in a bridge circuit designed for optimum conditions, taking account of the limit set by thermal noise and temperature fluctuations in the ambient around the bolometer foil. Optimum design features and operating conditions are summarized.

621.317.799:629.19 616
Electronic Instruments in Space-Research Vehicles—R. L. F. Boyd. (*J. IEE*, vol. 5, pp. 457–463; August, 1959.) The development of rocket-borne instrumentation is discussed with reference to the problems of special environmental conditions, power supply, and weight and size restrictions. The payloads of seven space vehicles are compared.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.74:621–52:621.396.934 617
High-Resolution Angle Transducer and Encoder—L. G. de Bey, D. Comstock, S. B. Peterson and R. C. Webb. (*Electronics*, vol. 32, pp. 78–81; October 16, 1959.) Equipment is described which will measure shaft position in missile tracking instruments to an accuracy within 0.001° for rotation rates up to 100°/second.

621.362:537.58 618
Thermoelectron Engines: Future Power Sources?—G. N. Hatsopoulos, J. Welsh and E. Langberg. (*Electronics*, vol. 32, pp. 69–72; November 13, 1959.) The basic principles and possible heat sources are reviewed. Three methods of reducing the space-charge potential barrier are discussed.

621.365.55:621.373.421.14.029.6 619
Microwave Generators with Enclosed Work Chambers for the Dielectric Heating of Food and Industrial Products—W. Schmidt. (*Elektron. Rundschau*, vol. 12, pp. 390–393 and 417–420; November and December, 1958; and vol. 13, pp. 13–16; January, 1959.) The theory of a magnetron HF generator, its design and practical construction, and related measurement problems are discussed.

621.38:[57+61 620
Biomedical Electronics—(*Proc. IEE*, vol. 47, pp. 1815–2010; November, 1959.) A collection of 25 papers relating to electronic applications in biology and medicine.

621.384.62 621
New Electrostatic Accelerator—I. Michael, E. D. Berners, F. J. Eppling, D. J. Knecht, L. C. Northcliffe and R. G. Herb. (*Rev. Sci. Instr.*, vol. 30, pp. 855–863; October, 1959.) The design and construction of a short, bakeable accelerator is described.

621.385.832:681.142 622
Character Displays using Analogue Techniques—S. C. Chao. (*Electronics*, vol. 32, pp. 116–118; October 23, 1959.) Fast read-out is obtained by forming characters on a CRT display from a series of overlapping dots. Resistor summing networks establish the dot positions.

621.385.833 623
Comparative Considerations on the Aperture Error of Symmetric and Asymmetric Uni-

potential Electron Lenses on the Basis of Measurements of the Emergent-Ray Tangents—K. J. Hanszen. (*Z. Naturforsch.*, vol. 13a, pp. 409–414; May, 1958.)

621.385.833 **624**

The Influence of Inelastically Scattered Electrons on the Contrast of Plane Objects in Electron Microscopes—W. Lippert. (*Z. Naturforsch.*, vol. 13a, pp. 274–278; April, 1958.)

621.387.4 **625**

Gas Čerenkov Counters—J. H. Atkinson and V. Perez-Mendez. (*Rev. Sci. Instr.*, vol. 30, pp. 864–868; October, 1959.)

621.387.4:621.383.27:535.37 **626**

Luminescent Effects in Photomultiplier Tube Faces and Plexiglas Čerenkov Detectors—K. A. Anderson. (*Rev. Sci. Instr.*, vol. 30, pp. 869–873; October, 1959.)

621.396.662:[615.8+621.365.5 **627**

Automatic Tuning of Medical and Industrial High-Frequency Generators—L. Rausch. (*Elektronik.* vol. 7, pp. 335–336; November, 1958.) A motor-driven tuner unit controlled by a phase-discriminator circuit is described.

621.397.331.2:621.386.842 **628**

An X-Ray Image Amplifier using an Image Orthicon Camera Tube—E. Garthwaite and D. G. Haley. (*J. Brit. IRE*, vol. 19, pp. 615–622; October, 1959. Discussion, pp. 622–623.) The special requirements of a television camera for use as an X-ray image amplifier are outlined, and details given of the special camera tube that has been developed.

621.398:551.507.362.2 **629**

Tracking Weather Satellites—(*Electronics*, vol. 32, p. 51; November 13, 1959.) A system for following and interrogating Tiros meteorological earth satellites is briefly described.

656.1:621.396.969.14 **630**

Measurement and Recording of Vehicle Speeds by means of Microwaves—H. Bürkle. (*Arch. tech. Messen*, no. 275, pp. R165–R168; December, 1958.) German battery-operated traffic radar equipment working at 3 cm λ is described.

PROPAGATION OF WAVES

621.371 **631**

Transfer of Transient Electromagnetic Surface Waves into a Lossy Medium—J. Keilson and R. V. Row. (*J. Appl. Phys.*, vol. 30, pp. 1595–1598; October, 1959.) A flat earth with uniform electrical properties is assumed and the ionosphere disregarded in the treatment which gives a solution showing characteristics of wave propagation and diffusion. The limits imposed by the losses on the signal bandwidth are discussed.

621.391.81.029.4 **632**

On Propagation Velocity of Electromagnetic Waves at Audio Frequency—Ya. L. Al'pert and S. V. Borodina. (*Radiotekh. Elektron.*, vol. 4, pp. 195–201; February, 1959.) Determination of the phase velocity of em waves in the range 1–20 kc by means of harmonic analysis of atmospherics and their phase characteristics. The results of the investigation can be used to determine the effective conductivity of the lower ionosphere.

621.391.81.029.51./.53 **633**

Further Studies of the Deviation of Low- and Medium-Frequency Ground Waves at a Coast-Line—B. G. Pressey, G. E. Ashwell and R. Roberts. (*Proc. IEE*, Part B, vol. 106, pp. 548–554; November, 1959.) Previous work is reviewed, and further experiments are described in which the transmitters were located at sea and directional measurements made on several sites on land. The deviation due solely to change in conductivity at the boundary is small compared with random errors attributed to ground irregularities and obstructions.

621.391.812.61.029.64 **634**

Investigation of the Character of Rapidly Fading Radio Signals along a Transmission Path of Medium Length above the Earth's Surface—A. A. Semenov and G. A. Karpeev. (*Radiotekh. Elektron.*, vol. 4, pp. 187–194; February, 1959.) A preliminary estimation of the effect of the underlying earth surface on the amplitude fluctuations of the reflected signal. The investigation is carried out by means of a 65-kw transmitter operating in the 3-cm band using a parabolic antenna with horizontal polarization. Signals are reflected from two standard reflectors located 15 and 36 km from the transmitter, one 30 meters higher than the other. Amplitude fluctuations are recorded on a cine film and graphs show the correlation with wind-velocity data during a period of 4 months.

621.391.812.62 **635**

Inadequacy of Scatter Mechanisms in Tropospheric Radio Propagation—P. C. M. de Belatini. (*Nature*, vol. 184, suppl. no. 20, pp. 1558–1559; November 14, 1959.) From a study of experimental results [*e.g.*, 2000*p* of 1959 (Kitchen, *et al.*)] it is concluded that the spatial field distribution is not random but essentially coherent. The fluctuations at a fixed point are due to shrinkage and expansion of the interference pattern with atmospheric changes.

621.391.812.621.029.64 **636**

Comparison of Computed with Observed Atmospheric Refraction—W. L. Anderson, N. J. Beyers and B. M. Fannin. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 258–260; July, 1959. Abstract, PROC. IRE, vol. 47, p. 2037; November, 1959.)

621.391.812.622.029.64 **637**

Influence of an Atmospheric Duct on Microwave Fading—F. Ikegami. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 252–257; July, 1959. Abstract, PROC. IRE, vol. 47, p. 2037; November, 1959.)

621.391.812.623 **638**

Diffraction Theory of Tropospheric Propagation Near and Beyond the Radio Horizon: Parts 1 and 2—O. Tukizi. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 261–273; July, 1959. Abstract, PROC. IRE, vol. 47, p. 2037; November, 1959.) See 3092 of 1959.

621.391.812.624:621.396.677 **639**

The Filling in of an Antenna Null by Off-Path Scattering on a Tropospheric Scatter Circuit—H. Staras. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 277–279; July, 1959. Abstract, PROC. IRE, vol. 47, pp. 2037–2038; November, 1959.)

621.391.812.624:621.396.96 **640**

Subhorizon Radar Echoes by Scatter Propagation—D. Atlas. (*J. Geophys. Res.*, vol. 64, pp. 1205–1218; September, 1959.) An extensive combination of diffuse and striated echoes out to a maximum distance of 85 miles was observed on a 3-cm 300-kw radar in Kansas for about 4 hours in September, 1956. Neither direct back scatter from the atmosphere nor superrefraction can explain the features of the display. The phenomenon is attributed to ground back scatter. The height and characteristics of the scattering centers which would be necessary to uphold this explanation are unlikely, but it is pointed out that the phenomenon is rare; a gross estimate of the rate of occurrence is 1 day in 10^4.

621.391.812.624.029.64 **641**

Microwave Scattering by Turbulent Air—C. E. Phillips. (IRE TRANS. ON ANTENNAS AND PROPAGATION, vol. AP-7, pp. 245–251; July, 1959. Abstract, PROC. IRE, vol. 47, p. 2037; November, 1959.)

621.391.812.63 **642**

Rhythmic Fading of Short-Wave Radio Signals—B. N. Singh and R. L. Ram. (*J. Atmos. Terr Phys.*, vol. 16, pp. 145–155; October, 1959.) The problem of fading is considered as equivalent to the superposition of two or more simple harmonic vibrations of similar frequencies and the results are applied to cases of interference between magneto-ionic components. Typical fading curves are considered with particular attention to those cases in which the MUF for the F_2 layer passes through the signal frequency.

621.391.812.63 **643**

Long-Wave Field Enhancement and Short-Wave Fading—A. Haubert. (*J. Atmos. Terr. Phys.*, vol. 13, pp. 379–381; February, 1959. In French.) The coincidence of fading on 6.2 mc with sudden field-strength fluctuations of 200-kc transmissions received in Rabat, Morocco, is investigated and an interpretation is given (see also 648 below). Recording of 200 kc transmissions may provide a better indication of SID than the present method of recording atmospherics at 27 kc.

621.391.812.63 **644**

Polarization Characteristics of Radio Wave Propagation in the Ionosphere—Y. S. N. Murty. (*Science and Culture (Calcutta)*, vol. 25, pp. 161–162; August, 1959.) Expressions representing polarization characteristics obtained from Appleton-Hartree ray formulas and from the wave formulas of Saha, *et al.* (243 of 1952) are shown to be identical.

621.391.812.63 **645**

The Refraction of Radio Waves by a Spherical Ionized Layer—E. Woyk (Chvojková). (*J. Atmos. Terr. Phys.*, vol. 16, pp. 124–135; October, 1959.) A general expression is derived for the refraction of a radio wave propagated obliquely in a spherically ionized layer. Both transmitted and reflected waves are considered. The special case of propagation along two fixed levels in an ionized layer appears naturally in the derivation of this expression.

621.391.812.63 **646**

Transient Modes of High-Frequency Radio Wave Propagation across the Auroral Zone—B. J. Fulton, L. E. Petrie and W. S. P. Ward. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 185–186; October, 1959.) These modes are clearly defined and appear at the same time as the normal single-hop modes. They have higher MUF's and greater time delays than the normal modes and are probably due to irregularities in the ionosphere along the great-circle path.

621.391.812.63:539.16 **647**

H-Bomb Explosion Effects on Radio Communication—S. G. Kingan. (*Short Wave Mag.*, vol. 17, pp. 321–322; October, 1959.) The influence of the two explosions in August, 1958, on ionospheric radio communications is discussed in relation to explosion height.

621.391.812.63:551.510.535:523.75 **648**

The Interpretation of Sudden Field Anomalies in the Long-Wave Range during Solar Flare Effects—E. A. Lauter and P. Třiska. (*Z. Meteorol.*, vol. 13, pp. 190–192; July/August, 1959.) Field-strength measurements were made on 155 kc simultaneously at distances 1360 and 950 km from the transmitter to investigate the effect noted by Haubert (643 above). The anomalies appear to be due to phase changes between ground and sky wave where the virtual height of reflection drops.

621.391.812.63.029.45 **649**

VLF Reflections from the Ionosphere in the Presence of a Transverse Magnetic Field—

N. F. Barber and D. D. Crombie. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 37–45; October, 1959.) The reflection coefficient is calculated for a sharply bounded ionosphere under conditions applicable to propagation around the magnetic equator. The reflection coefficient depends on whether the direction of propagation is from east to west or vice versa. Possible ways in which direct experimental evidence could be obtained are outlined.

621.391.812.63.029.51 650

Polarization Computations by means of the Multislab Approximation—A. J. Ferraro and J. J. Gibbons. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 136–144; October, 1959.) Calculations have been made by a method requiring digital computer techniques for determining the polarization of LF echoes due to reflection at vertical incidence. A comparison with the more rapid step method of Becker (*e.g.*, 672 of 1952) shows that this latter approach yields satisfactory results.

621.391.812.63.029.62 651

Evidence for a 200-Megacycles-per-Second Ionospheric Forward-Scatter Mode associated with the Earth's Magnetic Field—J. L. Heritage, S. Weisbrod and W. J. Fay. (*J. Geophys. Res.*, vol. 64, pp. 1235–1241; September, 1959.) Signals from a pulsed transmitter in southern Texas were received in California and Nevada in the vicinity of magnetic specular contours calculated for an assumed 100 km height. Rapid fading and broad azimuthal distribution were characteristic features and, although burst-like behavior was most common, steady signals were sometimes observed for 30-minute periods. No signals were received from the great-circle direction or north of it. Evidence of the nature and reliability of the scattering is presented.

621.391.812.8 652

The Effect of the Earth's Magnetic Field on M.U.F. Calculations—K. Davies. (*J. Atmos. Terr. Phys.*, vol. 16, pp. 187–189; October, 1959.) The effect of neglecting the earth's field in the deduction of MUF factor from a vertical-incidence ionogram is to reduce the factor to about 5 per cent below its correct value.

621.391.812.8 653

How Many M.U.F.s?—T. W. Bennington. (*Wireless World*, vol. 65, pp. 537–538; December, 1959.) Discussion of the term MUF and the various interpretations and values assigned to it in different circumstances, with particular reference to the recent CCIR assembly.

RECEPTION

621.391.81 654

The Propagation Conditions between Europe and North America in the 40–52-Mc/s Waveband during the Sunspot Maximum—H. Wisbar. (*Nachrichtentech. Z.*, vol. 11, pp. 586–590; November, 1958.) Data on the reception of U. S. amateur transmissions in the 5-meter band and of telephony transmission at 43.6 mc are analyzed with reference to f_0F_2 and geomagnetic conditions for periods between November 21, 1957, and March 8, 1958.

621.391.812.3 655

Some Remarks on the Analysis of Fading in the *m*- and *dm*-Range—J. Grosskopf. (*Nachrichtentech. Z.*, vol. 11, pp. 577–586; November, 1958.) Correlation methods of analysis and their application to VHF propagation tests are examined. Scatter-propagation theories are discussed with reference to measured correlation functions.

621.391.82:621.315.62 656

Radio Interference from H.V. Insulators—C. H. W. Clark. [*Elec. Rev.* (*London*), vol. 165, pp. 491–497; October 23, 1959.] The mechanism of interference generation by HV insulators is explained and the effect of insulator design is discussed.

621.396.62:621.317.794 657

The Sensitivity of a Radiometer with A.G.C.—N. V. Karlov. (*Radiotekh. Elektron.*, vol. 3, pp. 74–79; January, 1958.) Expressions are obtained for the sensitivity of a modulation-type radiometer in which the sensitivity threshold is controlled by means of an automatic gain control. It is shown that in practical applications this natural sensitivity threshold does not vary considerably.

621.396.62:621.376.3 658

A Quality-Checking Receiver for VHF FM Sound Broadcasting—C. G. Mayo and R. E. Jones. (*B.B.C. Engrg. Div. Monographs*, no. 25, 15 pp.; June, 1959.) Two receivers with the same basic design are described and the results of standard performance tests are given. In the final model, a combined limiter and discriminator circuit is used [1379 of 1958 (Mayo and Head)].

621.396.62:621.391.812.7 659

VHF/FM Multipath-Propagation Test Set—(*Wireless World*, vol. 65, pp. 559–562; December, 1959.) Description of the effects of multipath propagation on VHF FM signals and a full description of a test set developed to enable this type of propagation to be investigated and its effects evaluated.

621.396.66:621.372.56.029.6 660

Pre-Receiver Attenuator reduces Intermodulation—S. L. Robinette. (*Electronics*, vol. 32, pp. 64–65; November 6, 1959.) Brief details are given of a coaxial and a transformer type of magnetically controlled ferrite attenuator for UHF.

STATIONS AND COMMUNICATION SYSTEMS

621.391:621.376.5 661

Principle of Quantization of Stochastic Signals with Infinite Spectrum and some Results of the Theory of Pulse Transmission of Information—N. A. Zheleznov. (*Radiotekh. Elektron.*, vol. 3, pp. 3–18; January, 1958.) With pulse modulation, a potential fidelity in reception exists which cannot be exceeded with any form of modulation. A method is described for the selection of transmission-line characteristics guaranteeing this degree of accuracy.

621.396:681.84.087.7 662

A Method for the Stereophonic Transmission of Broadcasts—H. Jubisch and H. Seidel. (*Elektron. Rundschau*, vol. 12, pp. 377–382; November, 1958.) A system of normal bandwidth using amplitude and frequency modulation of a single carrier in the VHF band is described. Phase inversion is used to eliminate crosstalk.

621.396.2:523.5 663

Tests made on a Meteor-Burst VHF System—(*Brit. Commun. Electronics*, vol. 6, p. 781; November, 1959.) A three-year trial of the Canadian "Janet" intermittent communication system [910 of 1958 (Davis, *et al.*)] is reviewed. Stations 800 miles apart operated 2-kw transmitters at 49 mc using 5-element Yagi antennas and magnetic-tape storage. With a transmission speed during bursts of 2400 wpm, an average speed of 40 wpm with character error rate 0.35 per cent was obtained. Interference sources are noted.

621.396.41:551.507.362.2 664

Multiplexing Techniques for Satellite Applications—O. B. King. (*Electronics*, vol. 32, pp. 58–62; October 30, 1959.) A detailed account is given of the ten-channel transistorized time-division multiplex system used in the satellite Explorer VII. Particular reference is made to the gating technique, and to the means of analog conversion and storage of random input signals.

621.396.43:551.501.362.2 665

Satellite Communication—C. T. McCoy: J. R. Pierce and R. Kompfner. (PROC. IRE, vol. 47, pp. 2019–2020; November, 1959.) Comment on 2012 of 1959 with authors' reply.

SUBSIDIARY APPARATUS

621.3.087.9:621.374 666

Using Digital Techniques in Time Encoders—R. J. Sullivan, I. Eastman and I. C. Chanock. (*Electronics*, vol. 32, pp. 80–83; November 13, 1959.) A decimal indication of the elapsed time is given every 20 seconds. The output is suitable for either magnetic tape or paper chart recorders.

621.314.1:621.372.52 667

The Design of Transistor Push-Pull D.C. Converters—W. L. Stephenson, L. P. Morgan and T. H. Brown. (*Electronic Engrg.*, vol. 31, pp. 585–589; October, 1959.) The circuit least affected by external influences is a square-wave oscillator controlled by a saturating transformer. Design formulas are given.

621.314.1:621.382.3 668

Equations for Designing Transistor Power Supplies—T. Hamm, Jr. (*Electronics*, vol. 32, pp. 122–124; October 23, 1959.) Basic design equations and graphs for transistor dc/dc converters are given.

621.314.63:546.28 669

Operational and Storage Life of Silicon Rectifiers—C. L. Hanks. (*Electronics*, vol. 32, pp. 82–84; October 16, 1959.) Results are given of life-test measurements of forward voltage drop and reverse current.

621.314.63:621.311.6 670

Controlled Rectifiers drive A.C. and D. C. Motors—W. R. Seegmiller. (*Electronics*, vol. 32, pp. 73–75; November 13, 1959.) By using saturable magnetic-core firing circuits, the size and weight of switching devices are reduced. Half-wave and full-wave push-pull circuits are described.

621.314.63:621.382.2 671

Contribution to the Problem of Limiting Values for Semiconductor Circuit Elements—H. Carl and H. L. Rath. (*Elektrotech. Z.*, vol. 80, pp. 502–506; August 1, 1959.) The danger of exceeding the permissible voltage limits in series-connected power-rectifier elements is discussed. This difficulty can be overcome by the use of parallel resistors or capacitors as shown in the reverse-voltage/time curves given.

621.316.721/.722:621.382.3 672

Voltage and Current Stabilization with Power Transistors—W. Müller-Warmuth. (*Z. angew. Phys.*, vol. 10, pp. 497–499; November, 1958.) Basic circuits and design data and details of two power units are given.

TELEVISION AND PHOTOTELEGRAPHY

621.397.132 673

N.T.S.C. Colour-Television Signals—J. Davidse. (*Electronic Radio Eng.*, vol. 36, pp. 416–419; November, 1959.) Continuation of 335 of January. Experimental results are presented and theoretical consideration is given to the effects of prolonged high subcarrier levels and their influence on the luminance, and to the distribution of the momentary level of the luminance signal.

621.397.132 674

Transmission Faults in N.T.S.C. Channels—H. Schönfelder. (*Arch. elekt. Übertragung*, vol. 12, pp. 497–509; November, 1958.) The possibility of cross-modulation between luminance and chrominance signals and between saturation and line information even in linear transmission channels is considered. Studio circuitry for signal switching and distribution is investigated to assess distortion and cross-talk effects.

621.397.2:621.3.018.782 **675**

Waveform Distortion in Television Links: Part 2—The Measurement and Correction of Waveform Distortion—I. F. Macdiarmid. (*P.O. elec. Engrg. J.*, Part 3, vol. 52, pp. 188–195; October, 1959.) The techniques of waveform measurement and distortion specification are discussed. An "echo waveform corrector" is described in which suitably attenuated inverted replicas of a distorted waveform delayed or advanced in time are added to the distorted waveform to correct it. **Part 1**—4209 of 1959.

621.397.2:621.396.665 **676**

A New Approach to Balanced Audio Levels in Television—R. B. Monroe. (*J. Soc. Mot. Pict. Telev. Engrs.*, vol. 68, pp. 538–541; August, 1959.) In the system described AGC amplifiers with modified gain characteristics are used on conjunction with manual gain controls to balance AF levels.

621.397.2:681.84.087.7 **677**

Stereophonic TV Sound—(*Electronics*, vol. 32, p. 64; October 30, 1959.) A description of a multiplex system in which two AF channels are modulated at the horizontal synchronization-pulse frequency and applied to a conventional sound transmitter.

621.397.23 **678**

Synthetic Highs—an Experimental TV Bandwidth Reduction System—W. F. Schreiber, C. F. Knapp and N. D. Kay. (*J. Soc. Mot. Pict. Telev. Engrs.*, vol. 68, pp. 525–537; August, 1959. Discussion.) A complete system is described which codes a standard video signal to match a channel of narrower bandwidth and subsequently decodes the received signal for display on a standard television monitor.

621.397.6.001.4:535.623 **679**

Application and Future Development of the Test-Line Technique—H. Springer. (*Rundfunktech. Mitt.*, vol. 3, pp. 40–50; February, 1959.) Experimental transmissions of test lines during the vertical scanning interval by West German transmitters [see 587 of 1956 (Fröling)] were used to investigate white-level functions and to develop automatic white-level control equipment which is described. For English version see *E.B.U. Rev.*, no. 53A, pp. 2–11; February, 1959. Other papers on test-line technique are given in 1957 IRE NATIONAL CONVENTION RECORD, vol. 5, pt. 7, pp. 17–50.

621.397.61 **680**

The Television Transmitter Ochsenkopf—(*Rundfunktech. Mitt.*, vol. 3, pp. 2–28; February, 1959.) A group of papers dealing with the new high-power transmitter in North Bavaria:

a) **The State of Television Coverage in Bavaria after the Opening of the High-Power Television Transmitter Installation Ochsenkopf**—F. M. Daser (pp. 2–4).

b) **Television Covarage in the Region of the Ochsenkopf Transmitter**—E. Graff (pp. 5–7).

c) **Technical and Economic Problems of the Ochsenkopf Transmitter Installation**—E. Kessler (pp. 8–11).

d) **Load Specification and the Constructional Solution adopted for the Television Tower on Ochsenkopf**—F. Staiger (pp. 11–14).

e) **Planning and Construction of the Television Tower on Ochsenkopf**—G. Jauch (pp. 15–18).

f) **Technical Equipment of the Television Tower on Ochsenkopf**—E. Angermüller (pp. 19–28).

For a description in English of the television tower, see *Engineer* (*London*), vol. 207, pp. 863–864 and 901; May 29, and June 5, 1959.

621.397.61 **681**

High-Power Television Transmitters for Bands IV and V—T. S. Robson and T. M. J. Jaskolski. (*Proc. IEE*, Part B, vol. 106, pp. 528–540; November, 1959.) The power requirements of transmitters are considered in relation to the limited coverage obtainable at UHF. Details are given of the Crystal Palace transmitter for propagation tests covering the 405- and 625-line systems.

621.397.61.029.63 **682**

High-Power Television Transmitter for Bands IV/V (Haardtkopf)—A. Kolarz and A. Schweisthal. (*Rundfunktech. Mitt.*, vol. 3, pp. 29–39; February, 1959.) Description of a complete transmitter installation in southwest Germany with high-power klystrons in the output stages.

621.397.62:616–001.26 **683**

X-Ray Emission from Television Sets—C. B. Braestrup and R. T. Mooney. (*Science*, vol. 130, pp. 1071–1074; October 23, 1959.) An estimate is made of the average radiation dose to the gonads from home television sets based on measurements on typical television tubes.

621.397.743 **684**

Gap-Filling Translators and Transmitters—W. J. Morcom. (*J. Brit. IRE*, vol. 19, pp. 649–659; October, 1959.) A general description of the system and apparatus used in low-power television booster stations with details of the performance specifications.

621.391.81:621.397 **685**

The Field Strengths required for the Reception of Television in Bands I, III, IV and V—G. F. Swann. (*Proc. IEE*, Part B, vol. 106, pp. 541–544; November, 1959. Discussion, pp. 545–547.) The characteristics of the receiving installation are considered together with the statistical variation of field strength with antenna location. The nominal limit of the service area in terms of median field strength is then derived.

TUBES AND THERMIONICS

621.382.2 **686**

Measurement of Thermal Behaviour of Semiconductor Diodes—O. Jakits. (*Elektrotech. Z.*, vol. 80, pp. 518–520; August 1, 1959.) Measurements of thermal inertia are interpreted on the basis of a simplified model. See also 3109 of 1959.

621.382.2:546.681'18 **687**

Electrical Characteristics of some Gallium Phosphide Devices—J. Mandelkorn. (PROC. IRE, vol. 47, pp. 2012–2013; November, 1959.) Characteristic curves of GaP diodes are given; these devices are potentially useful for high temperature work and in rapid switching. A few showed curves very similar to those of a Ge point-contact transistor.

621.382.2:621.317.3 **688**

The Measurement of Semiconductor Diode Switching Characteristics—Barry and Fisher. (See 601.)

621.382.2:621.375.9 **689**

Semiconductor Varactors using Surface Space-Charge Layers—W. G. Pfann and C. G. B. Garrett. (PROC. IRE, vol. 47, pp. 2011–2012; November, 1959.) Such devices could be made by bringing together an *n*-type semiconductor and a nonconducting oxide. They should compare favorably with *p-n* diodes for parametric amplifiers both in respect of cutoff frequency and capacitance voltage characteristic.

621.382.2:621.375.9 **690**

Alloyed, Thin-Base Diode Capacitors for Parametric Amplification—Mortenson. (See 441.)

621.382.23 **691**

The Temperature Dependence of the Electrical Characteristics of the Silicon Alloyed Junction—H. Izumi. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 123–132; April, 1959.) A report of observations made on pointed-junction diodes in the temperature range 20°K–373°K.

621.382.23 **692**

The Time Lag of *p-n* Junction Diodes Strongly Driven with Sinusoidal Voltages—W. Heinlein. (*Arch. elekt. Übertragung*, vol. 12, pp. 510–514; November, 1958.) The theory given is confirmed by the results of tests on Ge diodes driven at different frequencies. See also 2767 of 1959.

621.382.23 **693**

The Tunnel Diode—Its Action and Properties—B. Sklar. (*Electronics*, vol. 32, pp. 54–57; November 6, 1959.) Electron energy-band diagrams are used to explain the negative conductance property of a semiconductor with high impurity concentration. Breakdown characteristics are illustrated and the equivalent circuit of a tunnel-diode amplifier is given.

621.382.3 **694**

Special Semiconductor Issue—(*Elektrotech. Z.*, vol. 80; August 1, 1959.) The following papers, which are mainly reviews of transistor applications, particularly in German equipment, are included in this issue; others are abstracted separately.

a) **Semiconductor Components, their Physical Properties and Technical Development**—H. J. Thuy and R. Wiesner (pp. 473–480). 115 references.

b) **Application of Semiconductor Components in Radio and Television Engineering**—E. Ginsberg (pp. 481–483).

c) **The Transistor in Telecommunications by Wire**—T. F. Grewe (pp. 483–487).

d) **Transistors in Control Systems with Logical Circuit Elements**—E. Götz, H. C. Heinzerling and H. G. Lott (pp. 487–492).

e) **Semiconductors in Telecontrol**—A. de Quervain (pp. 492–495).

f) **Transistors in Digital Measurement Techniques**—B. Rall (pp. 495–498).

g) **Transistor Switching Circuits in Automatic Computers**—H. Weber (pp. 498–502).

h) **The Silicon Rectifier in Converter Techniques**—E. Nitsche and F. Pokorny (pp. 506–512).

i) **Application of Power Rectifiers in Charging Equipment**—J. Balkow (pp. 512–514).

j) **Chopper Circuits with Transistors**—E. Gelder (pp. 520–522).

621.382.3 **695**

The Physical Interpretation of Measurements on Transistors—S. Deb. and A. N. Daw. (*J. Electronics Control*, vol. 6, pp. 552–553; June, 1959.) Comment on a criticism by Hyde (*J. Electronics Control*, vol. 6, pp. 362–364; April, 1959) of an earlier paper by the authors (2043 of 1959).

621.382.3:621.318.57 **696**

The Electrical Properties of Storage-Type Switching Transistors—W. v. Münch. (*Nachrichtentech. Z.*, vol. 11, pp. 565–571; November, 1958.) The characteristics of the transistor, described in 2777 of 1959 (v. Münch and Salow), are derived and discussed.

621.383:535.215 **697**

Photoresistors, Photodiodes and Phototransistors: Properties and Characteristic Data—P. Görlich, A. Krohs and W. Lang. (*Arch. tech. Messen*, nos. 274 and 275, pp. 235–238 and 247–250; November and December, 1958.) Details are given of a number of commercial types of international manufacture. See also 3520 of 1959.

621.383:535.376:621.375.9 698

Electroluminescent Cell Applications—Lochinger and Stutt. (See 442.)

621.385:534.29 699

Microphony of Thermionic Valves—A. Stecker. (*Elektronik*, vol. 7, pp. 361–367; December, 1958.) Examples of stroboscopic analysis are given. See also 1013 of 1959.

621.385.032.213.13 700

The Study of Interface Layer of Oxide-Coated Cathode by X-Ray Diffraction Method—T. Imai and H. Niizeki. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 55–70; March, 1959.)

621.385.3.004.6:621.395.64 701

The Life of Wide-band Amplifier Tubes—T. Kojima and H. Hara. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 36–43; February, 1959.) Factors which control the life of tubes for coaxial-cable repeaters are given.

621.385.61 702

Amplification of Space-Charge Waves in the Movement of a Beam of Electrons with Variable Velocity through Channels in a Medium with Ohmic Losses—Yu. F. Filippov. (*Radiotekh. Elektron.*, vol. 4, pp. 228–232; February, 1959.) Theoretical investigation of the propagation of a modulated beam with variable velocity in a medium with ohmic losses. Expressions are derived for a particular case of exponentially increasing waves.

621.385.6 703

The Motion of a Beam of Electrons Moving with Periodically Varying Velocity through the Channels of a Medium with Ohmic Losses—Yu. F. Filippov. (*Radiotekh. Elektron.*, vol. 4, pp. 233–240; February, 1959.) Theoretical investigation of the phenomenon occurring when an electron beam moves through a porous medium with ohmic losses. Contrasting with the case of propagation of an electron beam in vacuum, exponentially increasing waves exist for all values of the parameters of the beam and the medium. It is shown that the presence of thermal velocity does not lead to a critical frequency.

621.385.6:621.3.032.269.1 704

Experimental X-Band Preamplifier Tubes with 4.5 db Noise Figure—J. E. Nevins and M. R. Currie. (Proc. IRE, vol. 47, pp. 2015–2016; November, 1959.) The low noise is achieved by improving electron gun design.

621.385.623.5 705

Experimental Investigation of the Synchronous Operation of Reflex Klystrons in the Three-Centimetre Band—S. D. Gbozdover, A. I. Kostienko and G. P. Lyubimov. (*Radiotekh. Elektron.*, vol. 3, pp. 105–111; January, 1958.) The paired-series synchronous operation of several reflex klystrons operating into a common load with displaced frequency characteristics is examined. It is shown that this operation can be accomplished without discontinuities in the frequency spectrum or in the generated power. The tuning range for systems of several klystrons may exceed the sum of the separate tuning ranges.

621.385.623.5 706

The Effect of a Load on the Synchronous Operation of Two Reflex Koystrons—A. I. Kostienko and G. P. Lyubimov. (*Radiotekh. Elektron.*, vol. 3, pp. 112–115; January, 1958.) Experimental investigation of the dependence of the bandwidth of synchronization and the tuning range of two synchronously operating klystrons on the impedance/frequency characteristic of the load in the 3-cm range.

621.385.623.5:621.317.34 707

The Spectral Density of the A.M. Noise in Reflex Klystrons—H. Häggblom. (*Proc. IEE*, Part B, vol. 106, pp. 497–500; November, 1959.) The AM noise spectrum is treated experimentally and theoretically for signal frequencies of 4.7 and 9.3 kmc. By considering the synchronizing effect of the RF components in the electron beam, the theory gives a nearly constant noise spectrum within a relative bandwidth of about 10^{-4}–10^{-3}.

621.385.624 708

Triple-Resonator Klystron Frequency Multipliers—A. D. Sushkov. (*Radiotekh. Elektron.*, vol. 4, pp. 246–252; February, 1959.) Description of a triple-resonator klystron with preliminary signal amplification and with different frequency multiplication factors. Theoretical and experimental results are examined. Comparison of the performance of triple-resonator and double-resonator types shows the superiority of the former.

621.385.624 709

Frequency Conversion with a Reflex Klystron—E. N. Bazarov and M. E. Zhabotinskii. (*Radiotekh. Elektron.*, vol. 4, pp. 253–261; February, 1959.) Mathematical analysis indicating theoretically the possibility of using a reflex klystron for frequency division and multiplication. Five operating modes are considered and a new reflex klystron is proposed which can increase the coefficient of electron interaction during processes of frequency conversion. This klystron consists of two cavity resonators with three or four grids.

621.385.624 710

Some Experiments on Broad-Band C.W. Power Klystrons at X Band—M. O. Bryant and C. P. Lea-Wilson. (*J. Electronics Control*, vol. 6, pp. 481–498; June, 1959.) The experiments were designed to assess the bandwidth capability of a multicavity klystron for CW powers of several hundred watts. This is shown to depend on maximum electron current density and hence on magnetic focusing field. Its gain-bandwidth product is better than that of a traveling-wave tube, but not its efficiency-bandwidth product.

621.385.63 711

Computing the Power of Interaction between an Electron Beam and the Field of a Delay System with a Given Field Approximation—V. M. Lopukhin and G. A. Sitnikova. (*Radiotekh. Elektron.*, vol. 4, pp. 218–227; February, 1959.) Solution of the problem of the excitation of a slow-wave structure in which the field consists of a superposition of *n* harmonics with amplitudes that increase with the coordinates. Expressions are derived for the current density, the power of interaction between the electron beam and the field, and efficiency. A solution is obtained for the excitation of a traveling-wave tube with a variable average electron velocity; the effect of a variation in the average electron velocity on the excitation conditions for the system is examined. The effect of the space charge on the power of interaction between the electron beam and the field in an exponentially increasing wave is considered.

621.385.63 712

An Isochronous Travelling-Wave Valve—G. F. Filimonov. (*Radiotekh. Elektron.*, vol. 3, pp. 85–93; January, 1958.) The investigation shows the possibility of increasing by 3 db the high-frequency field of a traveling-wave tube. The effect of a number of parameters on the magnitude of this effect is also examined.

621.385.63 713

Nonlinear Theory of a Travelling-Wave Valve: Part 3—The Effect of the Repulsion Forces—L. A. Vainshtein and G. F. Filimonov. (*Radiotekh. Elektron.*, vol. 3, pp. 80–84; January, 1958.) An investigation of the effect of Coulomb repulsion forces on the operation of a traveling-wave tube amplifier. Nonlinear equations are used and results are compared with those obtained by other authors.

Part 1—2426 of 1959.

Part 2—vol. 2, pp. 1027–1047; August, 1957.

621.385.63 714

An Electron Beam in a Helix Placed in a Dielectric Medium—V. P. Shestopalov. (*Radiotekh. Elektron.*, vol. 3, pp. 131–141; January, 1958.) Investigation of em wave propagation in a helix located in a dielectric medium in the presence of an electron beam. Equations for the em field and the electron motion are derived. The dispersion equation is also examined and a graphical solution of this is shown.

621.385.63:621.375.9 715

Travelling-Wave Tube Equations including the Effects of Parametric Pumping—J. S. Cook and W. H. Louisell. (Proc. IRE, vol. 47, p. 2016; November, 1959.) A general set of equations is given for investigating the process of parametric amplification of space-charge waves in traveling-wave-tube electron beams. Other data on the derivation and application of the equations are to be published later.

621.385.632 716

Travelling-Wave Valve Oscillator with an Electronic Phase Shifter—M. V. Tychinskii and V. G. Fedorov. (*Radiotekh. Elektron.*, vol. 4, pp. 241–245; February, 1959.) Investigation of a traveling-wave tube oscillator with an electronic phase shifter located between the helix segments, the phase shifter being a drift tube with a controlled potential. Several oscillation ranges were observed in the frequency band near 3 kmc. The range of electronic tuning reached 4 per cent.

621.385.632.3 717

On the Theory of the Electron Wave Tube with Elliptic Cross-Section—P. Mattila. (*Acta Polytech.*, no. 241, EL1, 78 pp.; 1958.) Theory is derived and a comparison made with the electron wave tube of circular cross section.

621.385.633 718

Experimental Investigation of a Nonretarded Backward-Wave Oscillator—K. Ya. Lizhdvoi. (*Radiotekh. Elektron.*, vol. 4, pp. 212–217; February, 1959.) Results of an experimental investigation of an UHF oscillator using the interaction between an electron beam and an em wave having a phase velocity equal to the velocity of light. Graphs show the dependence of the wavelength on the flux density of the magnetic field and on the voltage of the electric field. A possible method of frequency modulation is examined.

621.385.64 719

A New Analysis of Magnetron—D. Kobayashi. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 100–115; April, 1959.) A general analysis which allows the calculation of the frequency of oscillation as a function of anode voltage and magnetic field.

621.385.64 720

Experimental Investigation of the Electronic Conductivity of the Space-Charge Cloud in a Magnetron—V. P. Tychinskii. (*Radiotekh. Elektron.*, vol. 3, pp. 116–130; January, 1958.) A description of a method for measuring the electronic conductivity and the cyclotron resonance curves in magnetrons. In several cases a satisfactory agreement was obtained between experimental and theoretical results.

621.387 721

Fluctuation of Starting Voltage in Gas-Discharge Tubes due to Statistical Time-Lag—T. Dote. (*Rep. elect. Commun. Lab., Japan*, vol. 7, pp. 116–122; April, 1959.)

Translations of Russian Technical Literature

Listed below is information on Russian technical literature in electronics and allied fields which is available in the U. S. in the English language. Further inquiries should be directed to the sources listed. In addition, general information on translation programs in the U. S. may be obtained from the Office of Science Information Service, National Science Foundation, Washington 25, D. C., and from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

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Express Contents of Soviet Journals Currently being Translated into English	Monthly	Advance tables of contents of translated journals		Consultants Bureau, Inc. 227 W. 17 St., New York 22, N. Y.
Technical Translations	Twice a month	Central directory in the U. S. of translations available from all major sources in the U. S.	OTS and Special Libraries Assoc.	Superintendent of Documents U. S. Gov't Printing Office Washington 25, D. C.

Publications of the Office of Technical Services

The Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., is the central facility in the United States for collecting and distributing unclassified technical reports of all U. S. Government agencies. Copies of these reports are available to the public at a price covering the cost of reproducing and handling. Their availability is announced in certain of the publications listed below. Also listed below are other OTS publications of particular interest to PROCEEDINGS readers.

The OTS also disseminates translations of foreign language articles. Further information about this activity is given under "Translations of Russian Technical Literature," which appears on the preceding page.

U. S. GOVERNMENT RESEARCH REPORTS

Lists and abstracts new Army, Navy, Air Force, Atomic Energy Commission, and other U. S. research reports available to industry. Published monthly. Sold by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $9 a year ($2.50 additional for foreign mailing), $1 per single issue.

TECHNICAL REPORTS NEWSLETTER

Reviews eight or ten U. S. Government reports believed to have particularly wide interest. Each issue usually contains several electronics items. Published monthly. Sold by Superintendent of Documents at $1 a year (50 cents additional for foreign mailing), 10 cents per single issue.

OTS SELECTIVE BIBLIOGRAPHIES

Bibliographies of research reports and translations in particular subject areas of wide industrial interest, such as transistors, printed circuits, and crystals. Prepared or brought up to date from time to time. Sold usually for 10 cents each. A list of these bibliographies may be obtained by writing to OTS.

NAVY RELIABILITY DESIGN HANDBOOK

Prepared by the Navy Bureau of Ships. Presents new information on materials, processes, techniques, and design aids, with emphasis on achieving greater simplicity, economy, and reliability in electronics equipment. Supplemented quarterly. Write to OTS for prices of the Handbook and the Supplements.

REPORT OF NRL PROGRESS

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PATENT ABSTRACT SERIES

Abstracts of U. S. Government-owned patents which have been released for use by private industry on a non-exclusive, royalty-free basis. Published periodically. Sold by OTS. Three of the volumes useful for radio engineers are: PB 111468 *Electrical and Electronic Apparatus*, $4; PB 111854 *Patent Abstract Series, Supplement No. 1*, $3.75; and PB 151510 *Electrical and Electronic Apparatus, Supplement No. 2*, $1.75.

SCIENTIFIC INFORMATION REPORT

Prepared by the Central Intelligence Agency twice a month. Reviews up-to-date scientific and technical developments in the Soviet Bloc as indicated from a review of the Bloc's popular and technical literature. One section is devoted to electronics. Sold by OTS at $28 a year ($4 additional for foreign mailing), $2.75 per single issue.

is model of the binary symmetric channel symbolizes the probability of error, p. How can a one received in the zero slot be caught and corrected?

Group codes for prescribed error patterns

formation signals, representing zeros and es, are transmitted through a binary sym- etric channel at such high speeds that they e subject to channel noise. Through group des it is possible to detect and correct tomatically large classes of errors that y arise from such disturbances.

Usually, in optimizing these codes all ssibilities are classified and samples of ch are evaluated. But this task can be- me enormously complex. For large infor- ation blocks, such as a 70-place code, ere may be billions of possibilities to evaluate. To reduce the need for these exhaustive methods, IBM scientists have evolved a preliminary theory for constructing group codes through a correlation analysis of error patterns.

Correlated patterns of errors are organized into equivalent classes and a code is formulated to overcome the error-producing characteristics of the communications channel. A code for one pattern of errors may be transformed mathematically into codes for other patterns of the same class. By prescribing which error patterns can be corrected, codes with a minimum number of checking signals may be formulated.

This optimizing process can have practical significance since every checking signal for a given number of information signals in a group code increases the cost and delay in information processing. In addition to the work described here, other approaches to the problem of code simplification are being made at IBM through linear programming and computer simulation.

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Whom and What to See at the Radio Engineering Show

(Continued from page 279A)

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New and Versatile High Speed Subminiature Toroid Coil Winding Machine Model #600, Capable of Winding Coils As Small As .055 I.D. To As Large As 2″ O.D. Without Changing Heads In Operation at Booth.

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See: Nicad Division.

Granite State Machine Co., Inc., Booth M-25
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Antennas, antenna control systems, antenna tuning systems, multicouplers, radar target simulators, servo-mechanisms, gears and gear trams, sheet-metal fabrications, technical publications.

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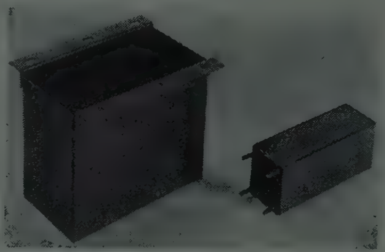
Div. of GEMP Manufacturing Corp.
22 Woodworth Ave.
Yonkers 2, N.Y.
Booth 4115

Lestern Weinberg, Armand Martel



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(Continued on page 284A)

Be sure to see all four floors!

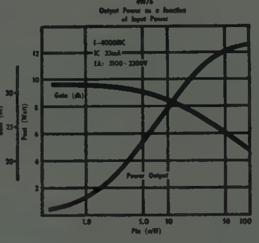
---

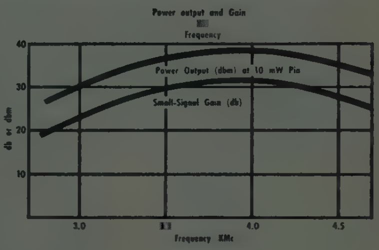
package-type TWT power amplifiers with NEC's new long life cathode

Production of traveling wave tubes at NEC began seven years ago and introduction of the package-type three years later. As chief supplier to Japan's complex network of microwave communications, NEC has become the world's largest maker of TW tubes. With the high development costs amortized and large manufacturing capacity, NEC is now able to supply these tubes at well below usual prices.

NEC's new doped nickel cathode core material, a 10-year development, increases both emission and tube life. It has been thoroughly field-proven in disc-sealed planar triodes for 2000-mc equipment of a large U.S. systems manufacturer (name on request). With its cooler operating temperature, evaporation rate of oxide is less than any other known core materials. This extends tube life up to 50%.

Designers will appreciate the compactness these tubes will give to their systems and operators the reliability and economy. Tubes connect to standard IEC waveguide flanges and can be shipped from stock.





4W76

The 4W76 operates in the 4000-mc band and has nominal saturated power output of 10 watts. High amplification over a wide range of power levels results in small-signal gain of approx. 30 db. The band width at half-power points is 1400 mc, but the tube can be used in the frequency range of 2800 to 5000 mc.

Typical Operating Characteristics at 4000 mc

First Anode Voltage	2,640 V	Saturated Power Output	12.5 watts
Helix Voltage	3,220 V	Small-Signal Gain	32 db
Helix Current	0.7 mA	Noise Figure	approx. 25 db
Collector Current	33 mA	VSWR	less than 2 to 1 (from 3500 to 4300 mc)
Focusing Electrode Voltage	-40 V		

NEC TRAVELING-WAVE AMPLIFIERS

PERMANENT MAGNET FOCUSED AMPLIFIERS

4W75	4000-mc band	1.5 watts	8W75	7000-mc band	1.5 watts
4W76	" "	5-10 watts	8W76	" "	5-10 watts
6W50	6000-mc band	5-10 watts	11W17	11000-mc band	1.0 watt

ELECTROMAGNET FOCUSED AMPLIFIERS

4W85	4000-mc band	0.1 watt	4W72A	4000-mc band	1.5 watts
4W86	" "	1.0 watt	7W52	6000-mc band	5-10 watts

Advantages of package-type

NO focusing or impedance matching at installation
NO dummy space for removal
NO power source or current stabilizer for electromagnet

NEC *Nippon Electric Company Ltd.* **Tokyo, Japan**
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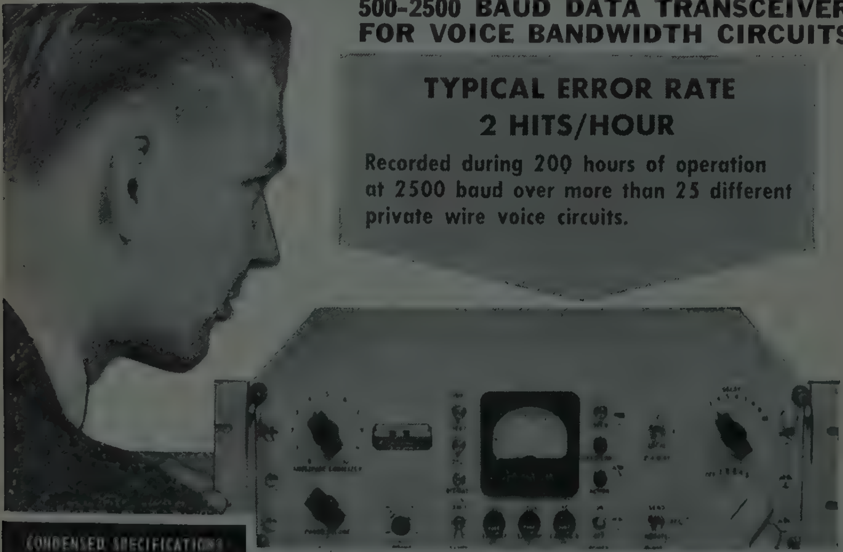

TYPICAL ERROR RATE
2 HITS/HOUR

Recorded during 200 hours of operation at 2500 baud over more than 25 different private wire voice circuits.

CONDENSED SPECIFICATIONS

REQUIRED SIGNAL TO RMS NOISE	12 db for error rate < 1 in 10^4; 14 db for error rate < 1 in 10^6
SPEED	600, 1200, and 2400 baud, 1500, 1667, and 2500 baud; any 3 predetermined rates between 500 and 2500 baud with internal synchronization or any rate between 500 and 2500 baud with external synchronization.
DELAY EQUALIZATION	Adjustable from 0.8 to 3.5 ms; frequency of max. delay settable from 1 to 2 kc.
TRANSMITTER INPUT LEVEL	+5 volts min., +50 volts max., ground-referenced digital information at bit rate.
TRANSMITTER OUTPUT LEVEL	—20 to +6 dbm
RECEIVER INPUT LEVEL	—40 to +10 dbm (Automatic Gain Control)
RECEIVER OUTPUT LEVEL	+20 volts ±10%, ground-referenced information at bit rate.

THE SEBIT-25 is a wire line terminal unit for transmitting and receiving binary information at 500 to 2500 baud (bits/sec) in a nominal 3-kc voice band, such as a long distance toll circuit. This simple AM system (SEBIT-25) uses vestigial sideband transmission and synchronous operation. It includes time delay and amplitude distortion compensating circuits. The equipment is 100% transistorized and has been carefully engineered to function properly under a wide variety of environmental conditions. Voice override is included so that the circuit can be used as an order wire. The SEBIT-25 finds use in transmitting: high speed data between business machines and computers; high speed facsimile information; time division multiplex information; and sequential transmitting of telemetering data. Write or phone for technical literature, prices, and delivery time.

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SEE BOOTH 3511—1960 IRE SHOW

Whom and What to See at the Radio Engineering Show

(Continued from page 282A)

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HRB-Singer, Inc., Booths 1819-1823
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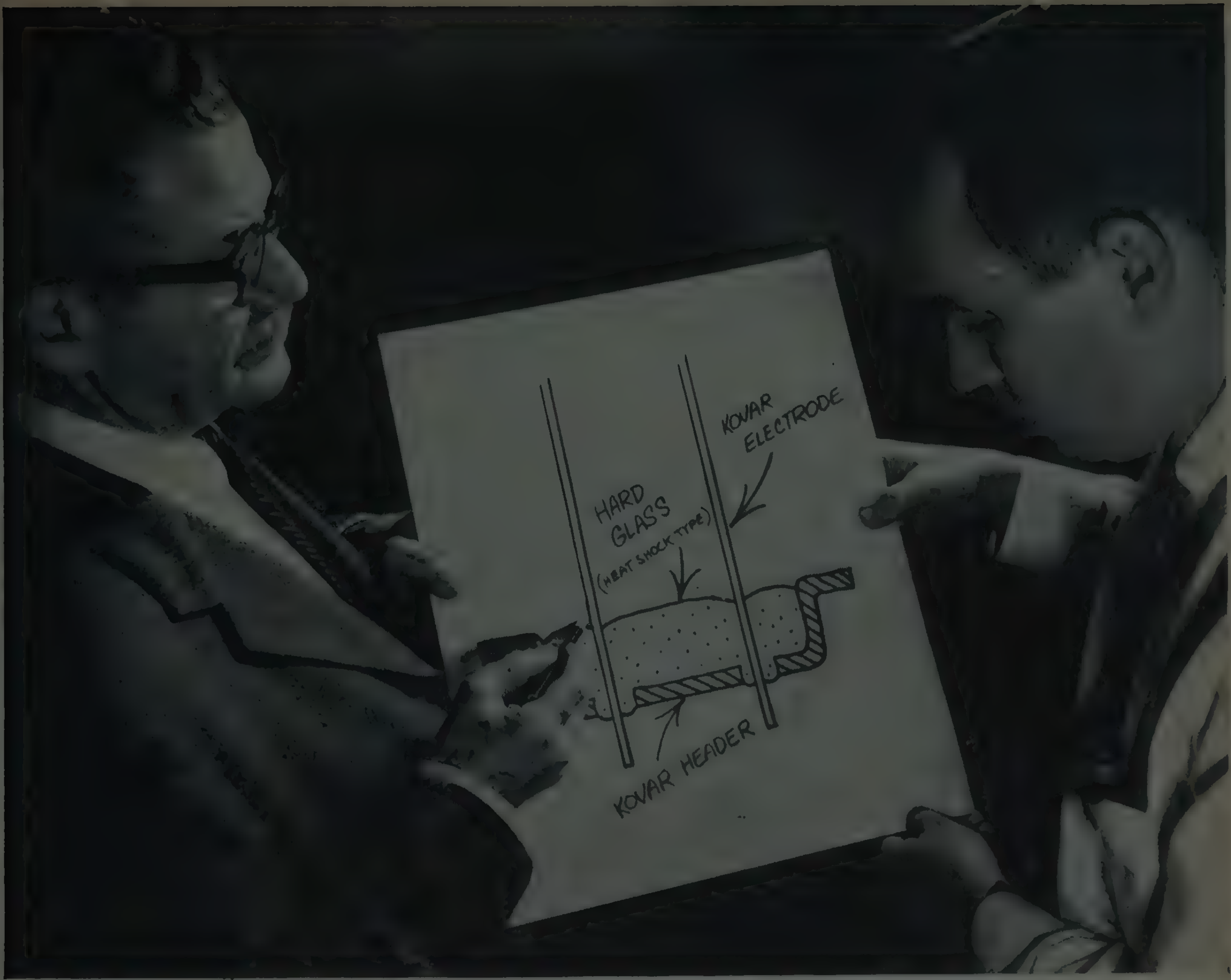
Haller, Raymond & Brown, Inc., Booths 1819-1823
See: Singer Manufacturing Co.

(Continued on page 286A)

CAFETERIA

Second mezzanine. Take elevator 16 from south side of any floor.



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FIND OUT ABOUT KOVAR WHERE IT IS USED AND WHY

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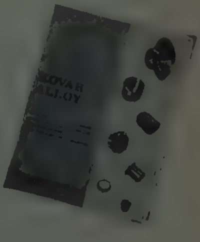

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Whom and What to See at the Radio Engineering Show

(Continued from page 284A)

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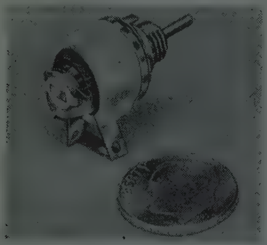

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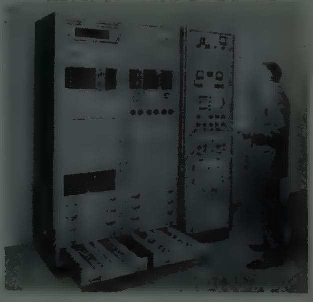
75 Cambridge Pkwy.
Cambridge 42, Mass.
Booths 3038-3039

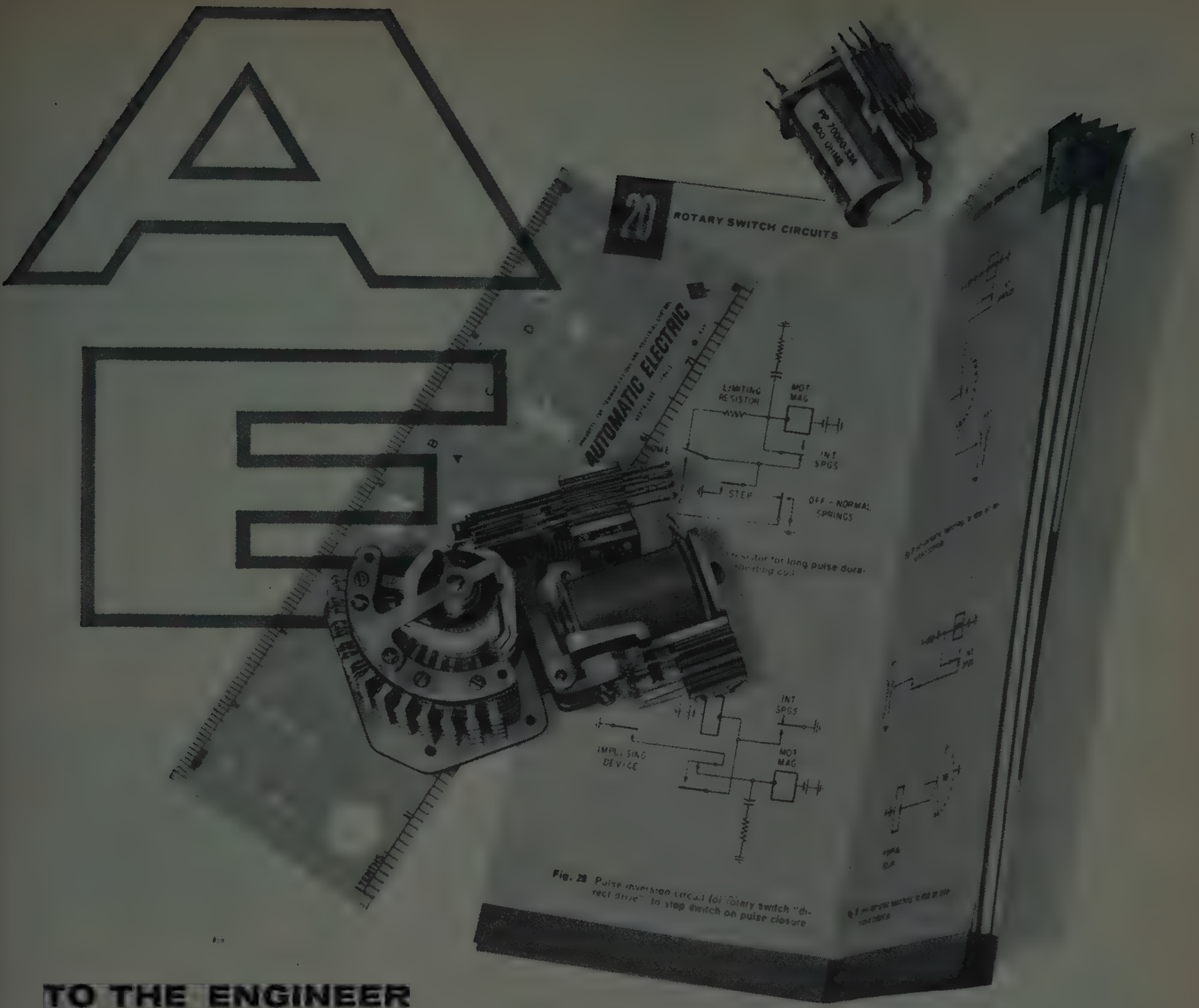
E. Phillips, ▲ H. Stevens, J. R. Martin, ▲ R. Wasserman, R. Downs, ▲ A. Madeson, ▲ D. Kosowsky, R. Joy, B. Weinstein, ▲ C. Hurtig



Hermes Radar Encoding System

Digital Timing Generators, Magnetic Tape Search Units, Ultra Stable Oscillators, Digital Language Translators, Crystal Filters and Discriminators, Voltage controlled Crystal Oscillators, Spectrum Analyzers, Frequency Synthesizers, Comb Filter Sets.

(Continued on page 288A)


20
ROTARY SWITCH CIRCUITS
AUTOMATIC ELECTRIC
LIMITING RESISTOR
MOT MAG
INT SPGS
STEP
OFF-NORMAL SPRINGS
IMPULSING DEVICE
INT SPGS
MOT MAG
Fig. 28 Pulse inversion circuit for rotary switch "direct drive" to step switch on pulse closure

TO THE ENGINEER

who needs "for instances"

Take such a "for instance" as this: you want to step an indirectly driven rotary switch immediately on pulse closure. The schematic, Fig. 28, above, points out an easy way of doing it with a standard relay.

Or suppose you'd like to stretch a pulse with a relay—or set up a sequential programming circuit with stepping switches. You'll find the most practical methods among the 41 schematics in AE's new 32-page booklet on "Basic Circuits." It comes complete with a handy template for drawing relays and switches on your own circuits. And it's all yours for the asking!

In case you don't find the solution to your switching problem in *Basic Circuits,* our engineers can find a solution for you. In fact, AE engineers can show you switching tricks that will cut corners on costs. Or, if you wish, they'll assume the job of designing and building to *your* specs, anything from a simple control package to an entire system.

To get your copy of *Basic Circuits* and/or the answer to your specific control problem, just write J. E. James, Director, Control Equipment Sales, Automatic Electric, Northlake, Ill. In Canada: Automatic Electric Sales (Canada) Ltd., 185 Bartley Dr., Toronto 16, Ont.

AE CAN DO

AUTOMATIC ELECTRIC

GENERAL SYSTEM

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

Whom and What to See at the Radio Engineering Show

(Continued from page 286A)

Hermetic Seal Corporation

29-37 South Sixth St.
Newark 7, N.J.
Booth 1223

▲ M. N. Glickman, ▲ Charles Ward, ▲ Lyle A. Backer, John D. Wood, Al Neumann, Donald E. Hempel, Daniel J. McCarthy, Warren Gressle, Gerald Muller, Joseph Spadafora, W. Speer, H. Perkins, F. Restaino

Hermetically sealed microminiatures, miniature and standard seals for relays, frequency control crystals, filters, condensers, rectifiers, transformers, transistors, diodes, Lock-In terminals and glass metal stems. AN connectors, pygmy and "Recon" (rack & panel rectangular) connectors. Gyro headers & terminals, non-magnetic true compression seals. Thermal time delay relays, high vacuum fuses.

Hetherington Switch Div., Controls Co. of America, Booth 1727
4218 W. Lake St.
Chicago 24, Ill.

Ed Kaufholtz, Dick Haws, Vern Kline, G. Maher

Industry's most complete line of lighted push-button switches (Switchlites). Also, complete line indicator lights, toggles, push-buttons and basic snap-action switches including environment-free and hermetically-sealed models. Custom electro-mechanical assemblies include holding coil switches, rotaries, interlocks.

Hewlett-Packard Co.

275 Page Mill Rd.
Palo Alto, Calif.
Booths 3302-3306, 3401-3405

▲ David Packard, ▲ William R. Hewlett, ▲ W. Noel Eldred, ▲ B. Oliver, ▲ C. Van Rensselaer, ▲ John Cage, ▲ A. Bagley, ▲ P. Stoft, ▲ N. Schrock, ▲ B. Wholey, ▲ P. Sherrill

Oscilloscope and Dual Trace Amplifier

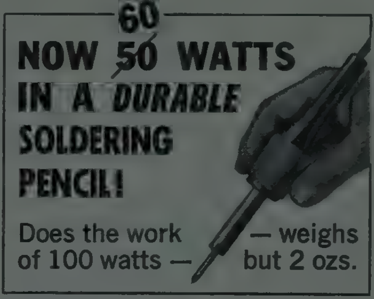
*Sampling Oscilloscope, *AC Vacuum Tube Voltmeter, *Militarized Oscilloscope, *Voltmeter Calibration System, *Frequency Standard System, *Frequency Standard, *Digital Recorder Clocks, *1.2 MC In-Line Counter, *M Band Waveguide, *Frequency Doubler Set, *Transistor Noise Figure Meter, *Transistor Amplifier, *Current Probe

See also: Boonton Radio Corp. & Dymec Division.

Hexacon Electric Co.

161 W. Clay Ave.
Roselle Park, N.J.
Booth 4012

R. Johnson, J. Grindrod, R. Leary, H. Neff, C. Ellingwood, L. Bryan, W. E. McFadden, J. V. McFadden, R. D. Wood, S. Adlam, R. Dunn, R. Bryan, A. Kulfan, R. Lunneau, J. Enders, R. L. Fish, R. H. Fish, G. Clouse, G. Hamilton, W. Ihlefeld, V. Gummert, A. B. Smith



NOW ~~50~~ 60 WATTS IN A DURABLE SOLDERING PENCIL!

Does the work of 100 watts — weighs but 2 ozs.

Featuring the *new XTRADUR Extra-Long-Life Tip. Doubles life of clad tips—outlasts copper tips 20 to 1. Solder adheres to working surface of tip only. Eliminates creeping of solder in tip hole and dropping of solder on components.

Hi-G Inc., Booth 2227
Bradley Field
Windsor Locks, Conn.

▲ Robert H. Wood, John A. Pfingsten, ▲ Douglas N. Wilson, ▲ Robert Farkas, ▲ Joseph A. Garratt, ▲ Michael M. Lanes, ▲ Alvin Lukash

Missile-type rotary-balanced armature relays. Standard AC and DC plus specially-designed versions. New series of tested *microminiature, *time-delay, *sensitive ESS, *special IF and RF coil assemblies. Time-delay relay control panel and new catalog.

Hi-Q Div., Booths 2603-2607
See: Aerovox Corp.

Hickok Electrical Instrument Co., Booths 3616-3618
10514 Dupont Ave.
Cleveland 8, Ohio

R. Hickok, F. Sawonik, K. Hughes, Dave Hughes, George Sutliff, Dave Wise, Ed Shortess, Robert Kerzman, Tom Clements

Line of research and development electronic test equipment including card programmed electron tube testers, oscilloscopes, microvolt, square wave, sine wave generators, VTVM's, stroboscopes, sound and balance measuring equipment. Line of friction-free meters. Line of transistor test equipment.

▲ Indicates IRE member.
* Indicates new product.

Hill Electronics Inc.

300 N. Chestnut St.
Mechanicsburg, Pa.
Booth 1903

J. A. Nickerson, ▲ B. C. Hill, Jr., R. H. Van Zandt, C. D. Bittner

Custom 1 pt 10^8 HEEMCO Accomplishment

Crystal Filters: Crystal Controlled Oscillators Engineered for the Customer. Low Frequency Quartz Crystals Capable of Meeting the Most Severe Shock and Vibration Requirements.

Carl Hirschmann Co., Inc.

30 Park Ave.
Manhasset, L.I., N.Y.
Booths 4533-4535

M. H. Kaefer, J. Bauer, H. Meier, J. Featherstone, A. Grillo, R. Meyer, E. Michow, M. Schrack

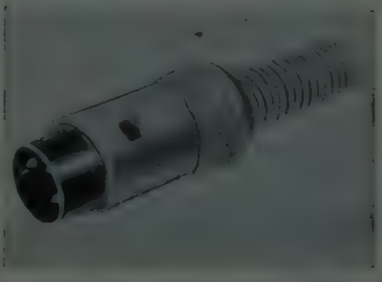
Micafil Precision Potentiometer Winder

MICAFIL—Most complete line of coil winding equipment. Small, low cost bobbin winder for laboratories, up to high speed relay winders 18,000 rpm., no cams, no gears to change. Toroidal, precision potentiometer and *fully automatic, high speed armature winding machines.

Richard Hirschmann Radiotecnisches Werk

c/o Rye Sound Corporation
145 Elm St., Mamaroneck, N.Y. &
1113 N. El Centro, Hollywood, Calif.
Booth 2933

Richard M. Livingston, ▲ S. M. Scher, Fred Hough, Irving Becker, Fred Rosenwasser, Richard Hirschmann, Pietre Geervliet, E. Flynn, D. Jaffee, P. Aaron



Hirschmann plugs, sockets, terminals. Miniature type plugs, connectors, and couplings for transistors and other small and standard size applications. Multiple connectors (2 to 36 poles); round, flat types; wire, panel, wall mounts. Alligator clips, banana plugs. Earphones, headsets, test products, miniature microphones, dictating machine accessories, sub-miniature components, ear plugs.

(Continued on page 290A)

DON'T MISS THE FOURTH FLOOR!

Production engineering is rapidly becoming one of the most important facets of the radio-electronic industry. Fourth floor exhibits are devoted to this subject. On the fourth floor, you can find new machinery and tooling techniques, and discover ways to make your own product better, cheaper and faster. Don't pass up this opportunity to acquire new methods and knowledge on that all-important aspect of electronics—

PRODUCTION—FOURTH FLOOR

INDIANA
GENERAL
CORPORATION

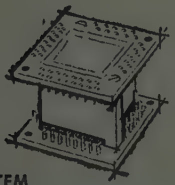
a new symbol of magnetic progress

Two established leaders — Indiana Steel Products and General Ceramics — Combine to Serve You Better

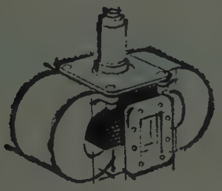
This trademark is the calling card of a new leader in science-age materials — Indiana General Corporation. It is born of a union between two established leaders — The Indiana Steel Products Company in permanent magnets . . . the General Ceramics Company in ferrites and memory systems. Together, as Indiana General Corporation, they serve you better by placing at your disposal the brains and resources of two scientifically oriented concerns. Research and development have been the backbone of both of the original companies; both have records of significant achievement in their particular fields.

Indiana General can help you "design-engineer" your products with the latest magnetic innovations. If you have a design problem, the Indiana General sales engineer in your area will be most happy to advise you. And, behind him, our experienced scientists and design engineers are available for consultations — at no cost or obligation. Write us outlining your problems.

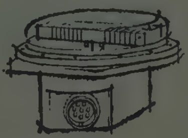
LOUD-SPEAKER
Indox V ceramic permanent magnet provides high energy level . . . reduces speaker length and weight.



MEMORY SYSTEM
New microstack unit for coincident current memory systems saves 90% of space required by conventional stack, yet is more reliable.



MAGNETRON
Powerful Hyflux Alnico V magnets improve performance in many types of microwave equipment.



AUTOMATIC DIRECTION FINDER
Ferramic "E" magnetic core material helped engineers create a new concept in aircraft antenna design.

This is Indiana General Corporation

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GENERAL CERAMICS DIVISION Keasbey, New Jersey • Ferrites, Memory Products, Technical Ceramics and Chemical Stoneware

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STEARNS MAGNETIC PRODUCTS DIVISION Milwaukee, Wisconsin • Magnetic Materials Handling and Separation Equipment

THE INDIANA STEEL PRODUCTS COMPANY OF CANADA LIMITED Kitchener, Ontario • Permanent Magnets and Stainless Steel Castings

If your product involves magnets or ferrites, Indiana General can help you make it better.

Visit us at the IRE Radio Engineering Show, *booths:* 1310-12-14-16

INDIANA GENERAL
CORPORATION
VALPARAISO, INDIANA

Whom and What to See at the Radio Engineering Show

(Continued from page 288A)

Hitemp Wires, Inc., Booth 4213
1200 Shames Dr.
Westbury, L.I., N.Y.

Walter Merck, Chris Wyer, Frank Lochridge, Robert Martin, William Frogner

High Temperature Wires and Cables. Bondable Teflon Insulated Wires. Ribbon Cables. Teflon Tapes. 1000° Flexible Insulated Magnet Wires.

Hoffman Electron Tube Corp., Booth 1520

See: E.M.I.-Cossor Electronics, Ltd.

Hoffman Electronics Corp.
Semiconductor Division
1001 North Arden Dr.
El Monte, Calif.
Booths 1920-1924

G. W. DeSousa, ▲ H. Schoemehl, B. Roberts, ▲ L. Rose, ▲ R. White, ▲ L. Swanson, ▲ W. Prenosil, R. Hoffman, D. Baldwin, H. Freudman, A. R. Cilia, R. Saichek

*Silicon Diffused Junction Mesa Transistors, *50 Watt Zener Regulator line, *Line of microminiature photo-voltiac (silicon) detector capsules, *Gridded Silicon Solar Cell, widest line of Zener Devices (diodes, reference units, regulators), Silicon Diodes and Rectifiers, Solar Cells.

Honeywell Controls Ltd., Booths 2202-2214

See: Minneapolis-Honeywell.

Hoover Electronics Company
110 W. Timonium Rd.
Timonium, Md.
Booth 3844

▲ A. J. W. Novak, ▲ H. K. Schoenwetter, ▲ H. H. Hoge, R. J. McCusker, R. P. Moore, J. B. Miller, G. S. Gay, T. E. Harrowby

Model 10057, Vernitel

*VERNITEL high accuracy FM/FM telemetering system components; *Millivolt Transistorized Subcarrier Oscillator; other transistorized telemetering products; special airborne electronic instrumentation; special electronic ground support and control equipment; special electronic test equipment; custom instrumentation vans and trailers.

Houghton Laboratories, Inc., Booth 4231

See: Hysol Corporation.

Hoyt Electrical Instrument Works, Inc., Booth M-17
42 Carleton St.
Cambridge 42, Mass.

V. S. Church, D. A. Hoyt, William Burton, ▲ George E. Morton

Electrical Indicating Panel Meters: 2% D'Arsonval DC milliammeters, microammeters, millivoltmeters, voltmeters, ammeters, high current shunts; matching 2% Repulsion AC types. Donut transformers. Case styles: 1½"-6"* plastic; 2½"-4½" bakelite; 2½"-8½" metal cases. 5% moving magnet indicators; DC milliammeters, ammeters, voltmeters.

Hudson Tool & Die Co., Inc., Booths 4408-4410
18 Malvern St.
Newark 5, N. J.

Ernest Isler, Ed Kuzma, Ken Naylor, Pete Church, Will Herbert

Complete line of deep drawn metal closures and covers—1800 various standard sizes from subminiatures to transformer sizes. Available in MuMetal, Stainless Steel, Aluminum, Brass, Copper, Steel, Monel and others on request.

We'll be seeing you again
at next year's show
March 20-23, 1961

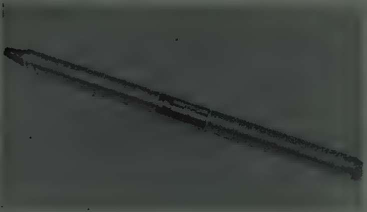
Men who know* prefer

Whom and What to See at the Radio Engineering Show

Huggins Laboratories, Inc.

999 E. Arques Ave.
Sunnyvale, Calif.
Booths 2917-2918

▲ Richard Huggins, ▲ Vern Varenhorst, ▲ William Fleig, Bruce Pruitt



Electrostatic-Focused TWT Amplifier

Traveling wave tube amplifiers and oscillators covering 250 to 18,000 mcs. Solenoid, PPM and electrostatic focusing: Low noise; low and medium power; high gain; broad bandwidth. *Ha-27, low power, electrostatic L-band amplifier. *HA-56, 5 watt L-band amplifier. *HA-58, 1 watt, electrostatic UHF amplifier.

See all the exhibits!

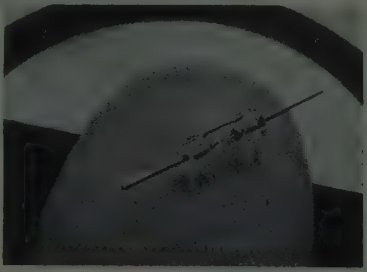
Don't miss these important locations—

Mezzanine at back of first floor, South Room at center of south wall, second floor, 3000 court at southeast corner of third floor, 4000 court at southeast corner of fourth floor, 4500 court in northwest corner of fourth floor.

Hughes Aircraft Co.

Florence & Teale Sts.
Culver City, Calif.
Booths 1609-1615

▲ M. D. Adcock, T. B. Aitkin, T. H. Anderson, W. D. Bird, Jr., R. J. Borstelmann, ▲ E. O. Bowers, J. M. Britton, C. C. Christ, ▲ B. A. Coler, B. W. Davis, J. B. de Groot, H. Dodson, ▲ I. Drukaroff, A. E. Fisher, W. Gould, A. Graydon, ▲ L. A. Gustafson, D. W. Harr, J. D. Hartley, J. P. Hughes, R. T. Jones, J. J. Kowall, J. R. Lyons, R. C. Martens, W. M. McHugh, B. O. Moxon, R. T. Orr, ▲ R. B. Reade, F. A. Salvatore, J. J. Stypa, ▲ J. J. Sutherland, J. J. Vogelzang, H. M. Wales, G. D. Wrench



Parametric Amplifier Diode

Diodes, Rectifiers, Transistors, Microelectronics*, Automobile Radio Silicon Capacitors*, Crystal Filters, Vacuum Gauge Tubes, Special Tubes, Vacuum Controls*, Welders*, Traveling Wave Tubes, MEMO-SCOPE® Oscilloscope, Multitracer, Scope Cart*, working model Parametric Amplifier*, New Microwave Components*, HC-105 Power Amplifier*, HC-11OHF Receiver Front End*, operating HC-120 Vocoder*, Nuclear Products (Radiation Effects*, Facilities*, Detectors*, Linacs*).

Hull Corporation, Booth 4114

Hatboro, Pa.

▲ Frank N. Cramton, Lewis W. Hull, John L. Hull, John H. Leary, Joseph Piotrowski, Lawrence L. Plummer

High Vacuum Relay Drying, Evacuating and Back Filling System. Completely automatic cycle using dry nitrogen for hermetically sealed relays. Completely automatic Transfer Molding Press for encapsulating small components such as diodes, semiconductors, etc., in latest type epoxy molding powders.

Hycon Eastern, Inc., Booths 3038-3039

See: Hermes Electronics Co.

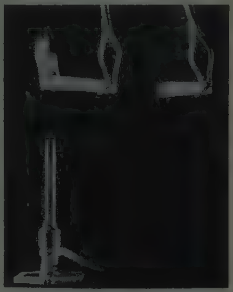
Hymac Corporation, Booth 3952

See: Molectronics Corp.

Hysol Corporation

Olean, N.Y.
Booth 4231

Reginald C. Whitson, ▲ William C. Jenner, Jean Cauchois, Jr., Patrick J. Scutella, Virgil Lorenzini, James A. Collins



Hysol Immediate Flame-Out Flexible Epoxy

*HYSOL 15-032, burn proof flexible epoxy casting compound meeting MIL-T27 ASTM and commercial laboratory burn test requirements. *HYSOL 6622 flexible epoxy casting compound family. HYSOL 6700 one component epoxy system. HYSOL fluidized bed and molding powders.

(Continued on page 294A)

You join the ranks of those who know* when you specify McMillan absorbers for *your* "free space" rooms. The list of McMillan customers is a veritable "who's who" in the electronics industry and includes such leaders as — Avco, Bell Labs, Bendix, Cambridge Research Center, Convair, General Electric, Johns Hopkins, MIT Lincoln Labs, Philco, Westinghouse and many others.

McMillan absorbers

- ✱ KNOW that from McMillan they can obtain substantiation to back up performance claims — either in simple, concise form or in advanced, scientific data.
- ✱ KNOW that each and every piece of McMillan absorber must pass an adequate source inspection to assure conformance to electrical specifications.
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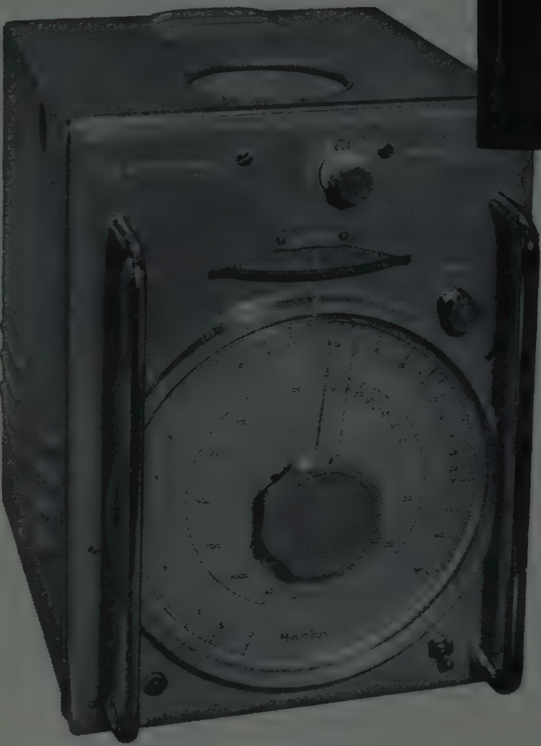
McMILLAN LABORATORY, INCORPORATED
BROWNVILLE AVENUE • IPSWICH, MASSACHUSETTS
See us at Booth 3237 — IRE Show, March 21 to 24

Here are some of the 27 Marconi instruments you should see!

MARCONI INSTRUMENTS

for Electronic Measurement



VHF ADMITTANCE BRIDGE MODEL 978

- Frequency range : 30 to 300 MC
- Measures conductance : 0 to 50 millimhos, ±2% ± 0.1
- Measures capacitance : −40 to +40 μμf, ±2% ± 0.5 (inductance measured as negative capacitance)
- Features high-stability servo-controlled conductance balance system

This simple, easy-to-use instrument is a general-purpose VHF bridge particularly suitable for measurements on unbalanced antenna systems, coaxial transmission lines, and distributed components in general, as well as on a wide range of lumped components. Operating in the range 30 to 300 MC, it fills the gap between slotted lines and conventional RF bridges. It is arranged for use with an external oscillator and detector, both of which can be supplied as optional accessories; alternatively a conventional VHF signal generator and receiver may be used.

FM SIGNAL GENERATOR Model 1066A

Frequency Range : 10 to 470 MC, on fundamentals throughout. 0.0025% short-term stability.

Direct-Reading Incremental Tuning : Stepped control up to ±15 kc; continuously variable from 0 to ±20 and 0 to ±100 kc.

Output Range : 0.2 μv to 200 mv at 50 ohms.

Modulation : FM deviation continuously variable and monitored from 0 to 20 and 0 to 100 kc. Also AM up to 40%. Modulation frequencies, 1 and 5 kc. Rack mounting version, Model 1066A/1, now available.

CARRIER DEVIATION METER Model 791D

Measures Deviation : 200 cps to 125 kc in four ranges; extended down to 10 cps using external readout.

Carrier Frequency Range : 4 to 1,024 MC, directly calibrated.

Modulation Frequency Range : 50 cps to 35 kc.

Crystal Locking : ensures freedom from microphony, allows measurement of FM hum and noise in VHF and UHF communication and broadcast transmitters.

Model 791D can be supplied for rack mounting.

at the IRE SHOW

BOOTHS 3301-03-05

Designers and Manufacturers of

AM & FM SIGNAL GENERATORS
AUDIO & VIDEO OSCILLATORS
FREQUENCY METERS · VOLTMETERS
POWER METERS · DISTORTION METERS
FIELD STRENGTH METERS
TRANSMISSION MONITORS
DEVIATION METERS · OSCILLOSCOPES
SPECTRUM & RESPONSE ANALYZERS
Q METERS & BRIDGES

TEST SETS FOR MOBILE RADIO

SIGNAL GENERATOR Model 1064A/2 and TRANSMITTER AND RECEIVER OUTPUT TEST SET Model 1065. Self-contained portable instruments for field testing mobile transreceiver sets. Signal Generator 1064A/2 provides RF outputs of 30 to 50, 118 to 185, and 450 to 470 MC, with FM deviation at 10 kc fixed and 0-15 kc variable; IF crystal outputs at five spot frequencies, and also an AF output. Test Set 1065 comprises an RF power meter and deviation indicator for use up to 500 MC, a dual-impedance AF power meter, and a multi-range voltammeter.

Model 1064A/2 above

Q METER
Model 1245

Frequency Range: 1 kc to 300 MC. **Measures Q:** 5 to 1,000: accuracy 5% at 100 MC. **Q Multiplier:** × 0.9 to × 2. **Delta Q:** 25-0-25. **Test Circuits:** separate LF and HF test circuits have ranges of 1 kc to 50 MC and 20 to 300 MC. **Capacitance Range:** 7.5 to 110 $\mu\mu$f with 1-0-1 $\mu\mu$f incremental, for either test circuit; 20 to 500 $\mu\mu$f for LF test circuit. **Shunt Loss:** 12MΩ at 1 MC. 0.3 MΩ at 100 MC. **External Oscillators:** Model 1247. 20 to 300 MC. Model 1246. 40 kc to 50 MC. Model 1101. 20 cps to 200 kc.

MAGNIFICATION

Model 1247

Model 1245

MARCONI INSTRUMENTS

111 CEDAR LANE, ENGLEWOOD NEW JERSEY
Telephone: LOwell 7-0607

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MARCONI INSTRUMENTS LTD · ST. ALBANS · HERTS · ENGLAND

TC168

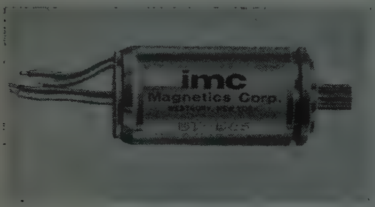
Whom and What to See at the Radio Engineering Show

(Continued from page 291A)

I.D.E.A., Inc., Booth 1327A
See: Industrial Development Engineering Associates.

IMC Magnetics Corp.
570 Main St.
Westbury, L.I., N.Y.
Booth 2229

S. Saretzky, J. Wohryzek, G. Egan, A. J. Silverman, A. H. Mankin, L. Seidner, R. W. Kopprasch, C. Burmeister, H. Lamkin, H. Kanter, B. Miller, B. Eder, C. Davis



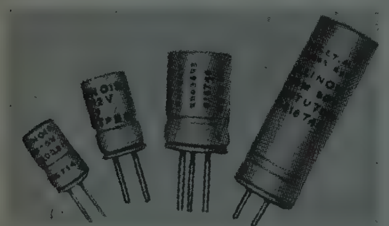
Size 5 Motor

Servomotors. ICM manufactures complete line 'PRECISIONEERED' servomotors 5 to 18; fractional and sub-fractional motors; dragcup and tach generators; DC motors and dynamotors; axial, vane axial, and centrifugal blowers; hysteresis and torque motors; synchros, stepping motors, solenoids; delay lines and pulse transformers.

ITT Components Div., ITT Federal Div., ITT Industrial Products Div., ITT Laboratories, Booths 2510-2520, 2615-2625
See: International Telephone & Telegraph Corp.

Illinois Condenser Co.
1616 N. Throop St.
Chicago 22, Ill.
Booth 2310

▲ J. J. Kurland, ▲ Joseph J. Kurland, L. W. Coleman



Motor Running—Motor Starting—Film Capacitors—Mylar, Polystyrene, Filters, Metallized Paper—Computer Capacitors— Special Quality Capacitors—Electrolytic Capacitors—Energy Storage Capacitors—Photo Flash Capacitors—Ceramic Encased Paper Capacitors—SMT Subminiature Capacitors.

Illinois Tool Works, Licon Switch & Control Div., Booth 1506
See: Licon Switch & Control Div.

Inca Manufacturing Div., Booths 4028-4029
See: Phelps Dodge Copper Products Corp.

Indiana General Corp., Booths 1310-1316
See: Indiana Steel Products Div. & General Ceramics Div.

▲ Indicates IRE member.
* Indicates new product.

Indiana Steel Products Div.
Indiana General Corporation
405 Elm St.
Valparaiso, Ind.
Booths 1314-1316

P. M. Wheeler, S. C. Beyerl, K. S. Talbot, P. R. Janes, V. B. Farr, J. R. Ireland, R. M. Handren, R. F. Smith, I. A. Dickey, R. W. Moore

Complete line of Indox, Alnico V-7*, Alnico VIIA*, Alnico and Cunife Permanent Magnets for the electronics industry. Magnet design consultation service on visitor's problems is offered. Magnetic Materials.

Induction Motors Corp., Booth 2229
See: IMC Magnetics Corp.

Induction Motors of California, Booth 2229
See: IMC Magnetics Corp.

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Industrial Hardware Mfg. Co., Inc., Booth 2837
See: Industrial Electronic Hardware Corp.

Industrial Instruments, Inc., Booths 3227-3229
89 Commerce Rd.
Cedar Grove, N.J.

L. C. Cunniff, ▲ G. Dzula, R. I. MacAuley, J. Williamson, R. Green, R. Kidder

Auto-Bridge Instruments for High-Speed Component Checking. Adaptable for Manual, Semi-Automatic, or Fully Automatic Handling Systems. Precision Bridges and Decade Units, Megohmmeters, Dielectric and Arc-Resistance Test Equipment, Hi-Pot Testers.

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Danbury, Conn.

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Booth 3513

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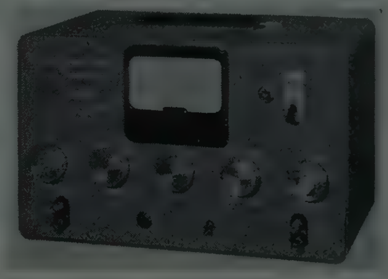

Phazor Phase Meter

*Phase meters, null meters, impedance comparators, *Power Oscillators, *Electronic Generators, frequency standards, automatic Hi-Pot Testers, *Phase shifters, and other electronic test equipment.

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Featuring ITVAC—Automatic Transistor Tester; Diffused Silicon Mesa Transistors, Germanium Alloy Junction Transistors, Silicon Rectifiers, Silicon Controlled Rectifiers.

(Continued on page 296A)

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VARIABLE FREQUENCY

VERSATILE

Microwave signal sources with high rf stability... for test, research, inspection.

Model 300

- INEXPENSIVE
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- Short-term stability — 1 part in 10^8.

10 mw power output for low power applications. Offers many features found only in much higher-priced instruments.

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NEW Series mounts from *FRONT* of panel in 15/32" clearance hole (supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 5 colors; give all-angle visibility. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-159B and L-162.

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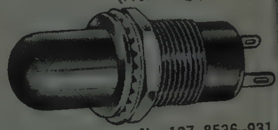

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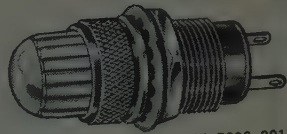
(Front mtg., 17/32")



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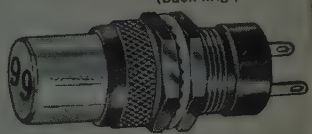
(Back mtg., 15/32")



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INCANDESCENT

2-TERMINAL and 1-TERMINAL TYPES

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Ask for Brochures L-156C thru 159B, and L-162.

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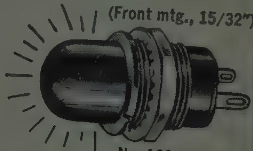

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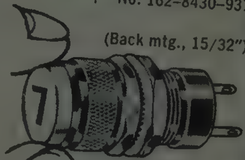
(Back mtg., 15/32")



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1-Terminal Pilot Lights

For use on *grounded circuits.* Mount in 13/32" or 15/32" clearance hole. Binding screw or soldering terminal.

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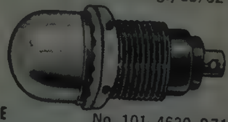

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Whom and What to See at the Radio Engineering Show

(Continued from page 294A)

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Union, N.J.

Jerome I. Cohn, H. H. Heyden, Dan Brandon, Vi Howell, Charles J. Kemp, John J. Lightner, Fred W. Link, Allen S. Nace, Homer Pacent, Walter M. Padiak, A. W. Pearsall, Clyde Rush, Frank Welling

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E. J. Tolle, ▲ George S. Burr, ▲ Donald R. Erb, L. F. Cedrone, Harold Hindman, Robert H. Flynn

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See: Instruments Publishing Co., Inc.

Instrument Development Labs., Inc., Booth 2106
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Publications: *Instruments and Control Systems, Instruments and Control Systems Buyers' Guide, Instrument & Apparatus News, Military Systems Design.* Books: Digital Techniques for Computation & Control, Automatic Control Technology, Printed Circuitry, Nuclear Reactors for Industry & Universities, Mechanical Measurements by Electronic Methods, Strain Gages and others.

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See: International Telephone & Telegraph Corp.

International Electronic Industries, Inc., Booth 4127

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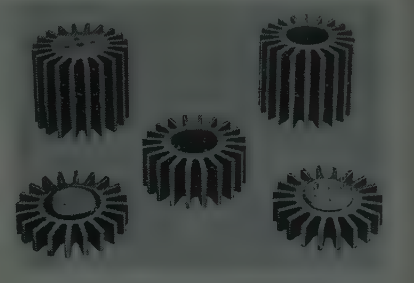
Booth 1522

Harvey Riggs, Don Rich, Fred Miller, ▲ John E. Markley, Jr., ▲ John C. McAdam, Ted Rafalovich



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Complete Line of Heat Dissipating Tube Shields and Tube Shield and Socket Assemblies Along With A New and Expanded Line of *Transistor Heat Dissipators. The Compact Design of Our New Transistor Heat Dissipator Allows the Design Engineer Greater Latitude In His Equipment Design.

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See: ELIN Division.

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Development & manufacture of Environmental Test Equipment including simulation of ultra-high, ultra-low temperatures, humidity, altitude, sand-dust, ranging from bench models to giant drive-in chambers. Ready for delivery is *new low-cost bench model ValuMite Temperature Test Chamber featuring 2 cubic feet of stainless steel test space.

(Continued on page 299A)

▲ Indicates IRE member.
* Indicates new product.

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The look is new,
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SINCE 1885

Whom and What to See at the Radio Engineering Show

(Continued from page 296A)

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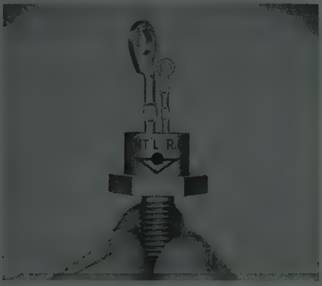

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Silicon Controlled Rectifiers*—1*, 10*, and 16* Amp-rated series. Complete line silicon zener voltage regulators; *Plug-In Silicon Equivalents to vacuum tube rectifiers; wide range silicon power rectifiers rated from 6 to 250 amperes per junction; silicon solar cells & *readout photocells for data handling systems; selenium photocells & sun batteries.

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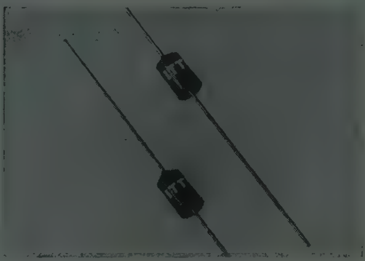

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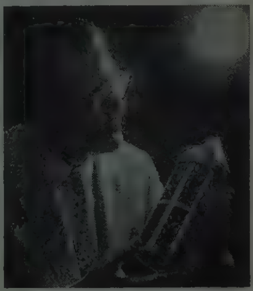

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World-wide SACCS Control System

Serves the electronic and communication industry with overall system management capability of high-speed completely integrated control systems including system analysis, system engineering and programming.

(Continued on page 300A)

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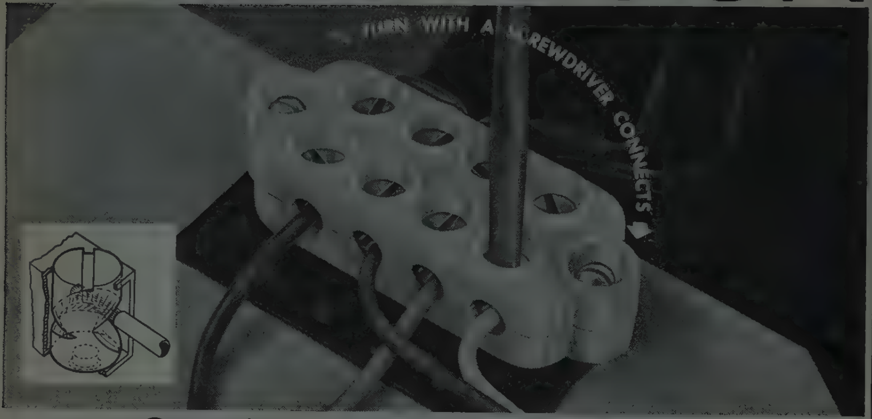
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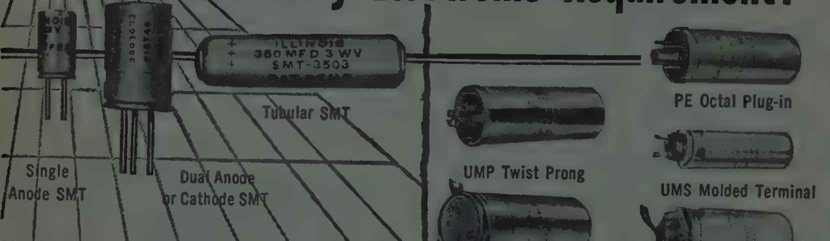
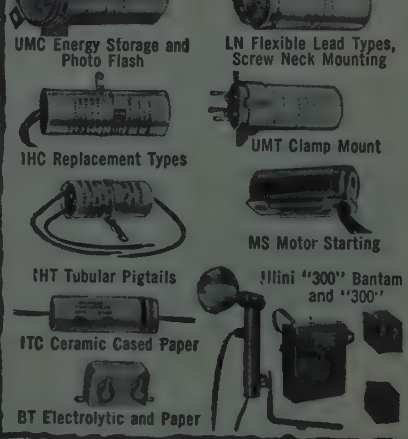

ILLINOIS
380 MFD 3 WV
SMT-3503
Single Anode SMT
Dual Anode or Cathode SMT
Tubular SMT
UMP Twist Prong
PE Octal Plug-in
UMS Molded Terminal


UMC Energy Storage and Photo Flash
LN Flexible Lead Types, Screw Neck Mounting
IHC Replacement Types
UMT Clamp Mount
MS Motor Starting
IHT Tubular Pigtails
Illini "300" Bantam and "300"
ITC Ceramic Cased Paper
BT Electrolytic and Paper

More than a quarter century of research and development is backed by the production facilities of four factories to produce electrolytic capacitors of any and every type to meet your requirements. Whether you need a small quantity of highly specialized types . . . or, large production quantities, you will find that we can offer you better service, PLUS many other advantages worthy of your consideration.

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Whom and What to See at the Radio Engineering Show

(Continued from page 299A)

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(Continued on page 302A)

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge and pocket card with you at all times on the floor. Registrations are not transferable.

TUNING FORK CONTROLLED PRECISION FREQUENCY PACKAGES

FROM 1.0 TO 4,000 CPS.

Overall accuracies from ±.05% to ±.01% over −55°C to +85°C range, and to ±.001% from zero °C to +75°C, **without** use of ovens.

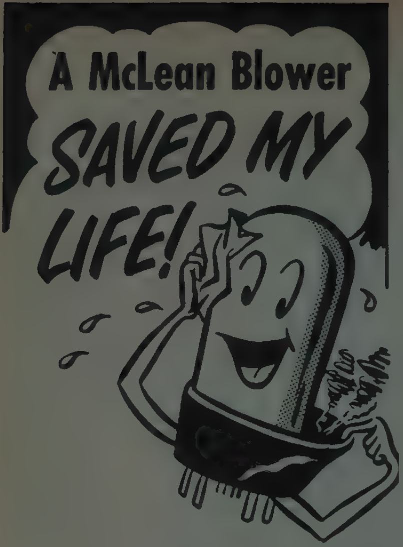
Silicon and germanium transistorized. Sinewave, squarewave and pulse outputs. 18, 20, 24, and 28 volt DC inputs.

Conservatively designed **reliable** units, potted in silicone rubber and hermetically sealed, for operation under **MIL** environmental conditions.

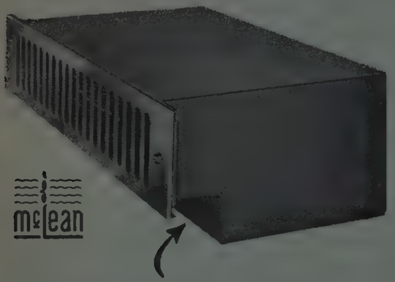
PHONE EDgewood 3-1700, or TWX WBRY 5103, or write:

PHILAMON LABORATORIES INC.

90 HOPPER STREET, WESTBURY, LONG ISLAND, N.Y.



I was about to fizzle out . . . the heat really had me! But that McLean Blower did the trick, and now I have a long life ahead.



McLEAN RECESSED MODEL
Permanent filter and blower recessed into unused portion of open base rack. Fit 3½", 5¼", 7", 8¾", and 10½" heights. Deliver 150 to 800 cfm.

Extend the life of sensitive tubes, transistors and other components with McLean packaged cooling units. Prevent system failure . . . maintain calibration and accuracy. Find out how in McLean's 1960 catalog . . . 44 pages of helpful information on cooling electronic equipment. McLean's rack-mounted fans and blowers are smart, compact, easy-to-install and have a multitude of mounting possibilities. Over 100 models in various panel heights and CFM's. Mil. Spec. equipment for packaged cooling also available.

WRITE TODAY
44 Page Packaged Cooling Catalog

McLean
FANS & BLOWERS

McLEAN ENGINEERING LABORATORIES
World Leader in Packaged Cooling
Princeton, N. J. • WAlnut 4-4440
TWX Princeton, New Jersey 636
See us at the IRE show—booth #1624

Whom and What to See at the Radio Engineering Show

(Continued from page 300A)

JFD Electronics Corp.

6101 Sixteenth Ave.
Brooklyn 4, N.Y.
Booth 1622

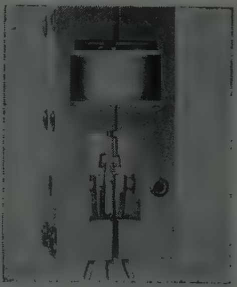
▲ Jack Goodman, ▲ Nelson Berman, ▲ Fred Strauss, Barrett Border, Robert Crawford, John Neenan, Richard Moran, Gunnar Hansen, Paul Wohl, Lew Salomon, ▲ Bob Bender, Joseph Murray

Development & Manufacture of Precision Metallized Variable Piston Capacitors (Glass & Quartz); LC Tuners, Metallized Inductors* (Fixed & Variable); Distributed & Lumped Constant Delay Lines* (Also Tapped & Variable); Filter Networks*, Diplexers*, Multiplexers*, Commercial & Military Antennas and Accessories.

James Electronics, Inc.

4050 North Rockwell St.
Chicago 18, Ill.
Booth 2100

▲ John A. Kennedy, ▲ Gerald W. Puce, Merwin E. Crowe



James introduces a new line of *Miniature Choppers, a new *Micro-Miniature Transformer Kit, Micro-Scan Sampling Relays, Specialized Input Transformers, Instrument Choppers and Vibrators.

James Vibrapowr Co., Booth 2100
See: James Electronics, Inc.

Japan Electric Industry, Dempa Shinbun, Inc., Booth 2935
2 Kanda Matsuzumi-cho, Chiyoda-ku, Tokyo, Japan &
629 Wellington Ave.
Chicago 14, Ill.

Genichiro Oguri, Hideo Hirayama, Hal Hirayama, George Taki

Semiconductor Products, Ceramic Variable Capacitors, IFTs, Oscillator Coils, Antenna Coils.

Jennings Machine Corp., Booth 4132
3452 Ludlow St.
Philadelphia 4, Pa.

T. J. Edwards, J. R. Peace, L. J. Mullin, K. Metz, R. Fleming

Automatic wire measuring, cutting and stripping, and terminal attaching machine.

Jennings Radio Mfg. Corp., Booths 1802-1804
970 McLaughlin Ave.
San Jose, Calif.

▲ Jo Emmett Jennings, ▲ Calvin K. Townsend, Robert E. Johnston, ▲ Lewis B. Steward, Don F. Hamm, Raymond B. McGill

Vacuum Fixed & Variable Capacitors, Vacuum Transfer Relays, and Vacuum Power Switches for use in High Powered Transmitters, Power Supplies, and Power Switching Applications.

Jerrold Electronics Corp.

15th & Lehigh
Philadelphia 32, Pa.
Booth 3056

▲ C. C. Cooley, ▲ K. Simons, ▲ A. Kirkaldy

Model 707 Variable-Rate RF Sweep Generator

Featuring latest measurement-by-comparison techniques for fool-proof, fast, accurate VSWR, Q, XL, Xc, and gain or loss measurement sweep generators with output flat to 5/100 DB and sweep width from 10 KCS to 400 MCS.

Jonathan Mfg. Co., Booth 4514
720 E. Walnut St.
Fullerton, Calif.

M. Fritz Hagen, Richard Becker, Charles Meyer

Chassis Slide Rails (ball bearing type) and Guiding Devices for Quick Servicing of Electronic Packages in Test Equipments, Missile Ground Systems, Computers and Other Instrumentation. New Products: *Jonathan Thinline Ball Bearing Slides With Tilting and Quick Disconnect Features.

Howard B. Jones Div.

Cinch Mfg. Co.
1026 South Homan Ave.
Chicago 24, Ill.
Booth 2535

E. J. Pool, S. Pfannstiehl, C. W. Nelson, J. G. Giampiccolo, J. M. Litman

Multi-contact plugs and sockets, barrier terminal strips, fanning strips, terminal panels, fuse mounts.

M. C. Jones Electronics Co. Inc.

Subsidiary Bendix Aviation Corp.
185 North Main St.
Bristol, Conn.
Booths 2222-2232, 2329-2331

S. T. Urbank, F. Roskosky, E. Testa, D. H. Coe, F. K. Clark

M.C. Jones
RF POWER and VSWR INSTRUMENTS

RF power and standing wave ratio measuring equipment 0.5 to 4000 mcs. directional couplers, dummy loads, coaxial line tuners, tunes to 1.000 VSWR.

Escalators at the south side of the main lobby take you direct to the Third Floor

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▲ Indicates IRE member.
* Indicates new product.

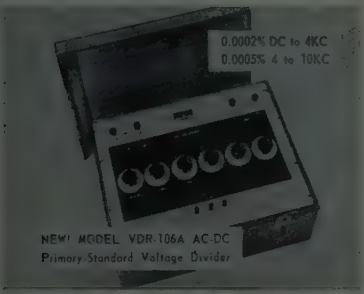
Jones & Lamson Machine Co., Booth 4030
Clinton St.
Springfield, Vt.

Harold Murch, John Barbier, James Allan, William Hinchcliffe, John Paul Jones, Vincent Lowe

Optical Comparator For Precise Component Inspection Equipped With New Super High Pressure Mercury Arc Lamp and New Surface Illuminator.

Julie Research Laboratories, Inc.
556 West 168th St.
New York 32, N.Y.
Booth 3238

▲ L. Julie, ▲ F. Bradley, B. Jacks, L. McCulley



***AC-DC Primary-Standard Voltage Divider**

Precision oil-immersed and encapsulated Resistors, Computer, Reactive, Instrument Networks, *Primary-Standard Instruments for AC and DC voltage, current, resistance measurements. Precision analog/digital converters.

Kanthal Corp., Booth 4425
Amelia Pl.
Stamford, Conn.

Erik Hagglund, ▲ G. W. Eisenbeis, R. C. Bossa, E. J. Chappa, P. E. Beach, J. Chester

Thermo-Kanthal, Thermocouple alloys. Fine gauge precision alloys for resistors and potentiometers. Kanthal DR and Nikrothal L with high resistivity and low temperature coefficients. Kanthal Super, molybdenum disilicide heating elements 1700°C. element temperatures.

Kay Electric Co.
14 Maple Ave.
Pine Brook, N.J.
Booths 3512-3518

H. R. Foster, ▲ E. E. Crump, John Gilmore, Tom Dougherty, ▲ Stanley Bara, ▲ Irving Silberg, ▲ William Hamer, ▲ Stanley Dickstein, ▲ George Murphy, Gerald Becker, ▲ Roy Huebner

***Noise Figure Measure Meter**

Attenuators, Sweep Oscillators, Noise Figure Measure, 1 KC—26,000 MC, *Automatic Noise Figure Measure, Pulsed Carrier Generators, Sound and Vibration Analysis Equipment, Transistor Test Set, 50 MC Cut-Off: Instruments For Analysis, Telemetered Signals, Radar IF's and Front Ends. Magna Sweep S-Band Sweep Oscillator.

(Continued on page 304A)

Elevators at north
and east sides
of the main lobby
take you direct to the
Fourth Floor

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE DIV. OF ALCOA, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

OPERATION SIMPLIFICATION. A high priority request from the Pentagon points to the big need for simplification in missile control and guidance systems. Fewer components and mechanical parts are what the Defense men are looking for in the hope of cutting down the numerous failures and malfunctions in missile performance. Along the same line, an Army Colonel has called for "deprovement" as a technique for design in military equipment. What he's looking for is stuff that's "smaller and worser" rather than "bigger and better." It's a wide open invitation and everyone is welcome to suggest possible solutions!

ELECTRIC CAR REVIVAL. Fuel cells that generate electricity when hydrogen and oxygen gases are fed into special carbon electrodes may spark a revival of the electric car. Resembling in some respects a big battery, the fuel cell might offer these advantages: silent operation; no smog-producing exhaust; economy because of the high (65% to 80%) efficiency. Some 20 companies are reported working on fuel cells for everything from satellites to outboard motors.

BIG VOICE FOR THE NAVY. By the end of this year the Navy hopes to have the world's most powerful radio station in operation at Cutler, Maine. The antenna system will have two arrays, each having a center tower 980 ft. high; an inner ring of six towers 875 ft. tall; and an outer ring of six towers 800 ft. high. Some 2200 miles of copper will be used in the ground system under the antenna arrays. With transmission output up to two megawatts, radio contact will be possible even with subs lying deep in the Arctic Ocean.

GUIDE TO TESTING. A detailed breakdown of what the Department of Defense demands in the way of environmental testing for electronic component parts is still available. Components fall into one of eight distinct groups and evaluation is done in terms of 12 test areas. Write to the Office of Technical Services, Dept. of Commerce, Washington 25, D.C. and ask for "Environmental Requirements Guide for Electronic Component Parts."

DUGOUT DATA. So far it's been man against man when rival baseball team managers try to outsmart each other. But soon baseball strategy will be decided by a computer. At least that is what's going on at the University of California, where a big computer is being "given its innings." The machine weighs the desirability of thirteen possible plays against the composite batting averages of the typical big league team.

CABLEMAN'S CORNER. The subject of cable testing is an important one. This is the phase of production that determines whether or not the cable you are purchasing is in accordance with your standards and requirements. In the field of electronics and automation, cables are required to suit various stringent electrical, mechanical, and/or chemical environments. Many years of study and testing have gone into the design of test equipment to be used for these critical tests. It is not enough to know that a cable has been tested in a manner that is "essentially" the same as the required standard. Slight variations in equipment design or methods of tests can mean the difference between conformance and non-conformance. Make sure the test data you receive gives a true picture of the performance of your cable. When you need cable, call on a cable specialist. Phone Rome 3000, or write to Rome Cable Division of Alcoa, Dept. 1230, Rome, N. Y.

These news items represent a digest of information found in many of the publications and periodicals of the electronics industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

⑯

Whom and What to See at the Radio Engineering Show

(Continued from page 303A)

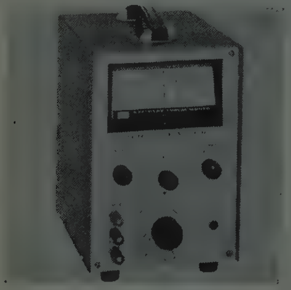
Kearfott Division
General Precision, Inc.
Little Falls, N.J.
Booths 1509-1511

William L. Quigley, George Dulay, Vincent O'Donnell, Jack Robertson, John McDonough, Henry Bloom, Frank Abate, Donald Chiafulio, Robert Wray, William E. Watson, James Rigley, Frank Crowley

Inertial Systems, Gyro Systems & Gyros, Servo System Components including Synchros, Servomotors, Tachometers; Test Equipment; Microwave Components; Ferrite Components; Analog-Digital Converters, Mechanical Computers; Radar Test Sets; Marine Electronic Equipment; Electrohydraulic components.

Keithley Instruments, Inc.
12415 Euclid Ave.
Cleveland 6, Ohio
Booth 3907

▲ J. F. Keithley, ▲ J. L. Gibson, ▲ P. Saint-Amour, ▲ J. Praglin, ▲ A. D. Oliverio, ▲ H. Sohn, ▲ R. Wood



Model 151 Null Detector

*Null Detector, *Research Micro-Microammeter; *Differential Input Electrometer, *Static Meter, *Regulated High-Voltage Supply, Microvolt-Ammeter, Milliohmmeter; Multi-purpose Electrometers, Megmegohmmeters, Linear & Logarithmic Micromicroammeters, Log and Period Amplifier, DC & AC Amplifiers.

Kellogg Switchboard & Supply Co., Booths 2510-2520, 2615-2625

See: International Telephone & Telegraph Corp.

Kelsey-Hayes Co., Booth 4002

See: Utica Drop Forge & Tool.

Kemet Company, Div. Union Carbide Corporation, Booth 2405
11901 Madison Ave.
Cleveland, Ohio

K. S. Collart, ▲ R. A. Dambach, ▲ G. H. Didinger, W. H. Fritz, D. H. Hollingsworth, D. J. Steigerwald, J. S. Wagener

Solid Tantalum Capacitors—Miniature high stability capacitors—for transistor amplifiers—R-C timing—Triggering circuits power supply and other applications—Semiconductor Silicon high purity grades for production of high quality transistors, power rectifiers and signal diodes.

Kemtron Electron Products, Inc., Booth 2825
14 Prince Pl.
Newburyport, Mass.

E. T. Casellini, A. N. Dugar, P. Anderson, M. Turtletaub, R. Berry, G. Hammond

Semiconductors, Silicon and Germanium point contact diodes for usage in microwave mixer, video detector and instrumentation circuits. Silicon junction medium power diodes for high and low voltage applications conventional or special mountings.

D. S. Kennedy & Co.
155 King St.
Cohasset, Mass.

Booths 2532 & 2637

▲ R. J. Grenzeback, J. C. Cotney, F. R. Hart, D. B. Kennedy, J. J. Flynn, ▲ A. R. Hawes

Spincastings for precision antennas. Antenna products. Waveguide components. Transmission towers for utility companies.

▲ Indicates IRE member.
* Indicates new product.

Be sure to see all four floors for a complete view of 800 new ideas!

Kepco, Inc.
131-38 Sanford Ave.
Flushing 55, L.I., N.Y.
Booths 2636-2638

Harvey J. Krasner, Max Kupferberg, George Hill, ▲ Kenneth Kupferberg, Jesse Kupferberg, Jack Kupferberg

0-325 V DC at 600 MA in 3½" panel

Voltage and Current Regulated Power Supplies. Transistorized, Vacuum Tube, Magnetic, and Hybrid Regulator Design. Bench, Rack Mounting, and Modular styles.

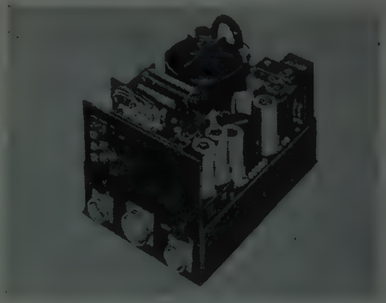
Kester Solder Co., Booth 4221
4201 Wrightwood Ave.
Chicago 39, Ill.

F. C. Engelhart, F. Kaiser, J. H. Humble, J. M. Johnson, C. L. Barber, ▲ J. E. Zaiser, E. Garfield, T. Sellaro, G. R. Clouse, G. R. Hamilton, H. E. Reed, J. Blakeley

Kester "44" Resin-Core Solder—Kester "Resin-Five" Core Solder—Other Flux-Core Solders—Kester "Solderforms" (Flux-filled & Solid Preformed Solder—all shapes and sizes)—Kester Solid Wire & Bar Solder—Kester Soldering Fluxes & Thinners—Kester Rosin Residue Removers.

Keystone Products Co.
904-6 23rd St.
Union City, N.J.
Booth 1911

E. M. Sokolowski, ▲ N. R. Grossner, W. H. Winchell, A. Ollick, E. Holewski



Filter-networks, toroids, magnetic amplifiers, transformers, electronic assemblies to customer requirements. Precision, high-reliability engineering and construction. Facilities for R and D of static magnetic devices. All components available encapsulated, molded or hermetic sealed to MIL specs.

Walter Kidde & Company, Inc., Booth 1925
Belleville 9, N.J.

Truman Young, R. Blake, N. Diepeveen, E. Demers, R. Gilbert, T. Jacobson, R. Langfelder, C. Klein, H. Matarazzo, W. Masnik, A. Jennings, C. Ware, E. Olsta

Thermistors, Relays, Converters, Power Supplies. Static relays & contactors for control & power applications, the "Freqconstat" ac to ac power frequency changer, dc to ac and dc to dc power conversion units, high temperature thermistors, radomes, solid state light flashers, aircraft fire detectors, & related solid state equipment.

(Continued on page 306A)

Special Purpose Wire

titanium
phosphor bronze
BERYLLIUM COPPER
Silvercote ®
ALUMINUM
ni-clad-ti
NICKEL CLAD (or plated) TITANIUM WIRE
FOR CERAMIC-TO-METAL BRAZING
round ● flat — square ■ half-round ⏜

Consider WIRE and the importance of its function in your product. Whether a highly engineered application or a simple stapling purpose, your choice of the proper alloy or composition, temper and type of wire could mean success or failure during crucial test.

● OTHER NON-FERROUS
Precision gauges from ½ to .002. Close tolerances held.

SPRING WIRE — WIRE FOR INSTRUMENTS — ELECTRONICS. STRAND FOR WIRE ROPE AND BRAIDED APPLICATIONS — MANDREL WIRE — WIRE FOR FORMS — RIVETS — STAPLING — OTHER.

LITTLE FALLS ALLOYS INCORPORATED
LFA
199 Caldwell Avenue Paterson 1, N. J.

YOURS TODAY–

A frequency standard so accurate that it measures time with a rate of change of less than one second in sixty years!

5×10^{-10}/DAY

The JK-SULZER FS1100T is a standard of frequency and time . . . born of and for the age of space.

Here is the precision scientists need for today's iew measurements of time, speed, direction and disance. Here is the stability to speed space exploraion, to broaden the application of molecular elecronics, and to aid such advanced studies as that nvolving Einstein's theory of special relativity. Here is a dramatic break-through in solid state physics design.

Yet, this stability of five parts in ten billion — esoteric as it may sound to some — is an accuracy routinely maintained by the JKFS-1100T — in a variety of field installations, for periods now approaching two years. In terms of the fast moving space age this is a long history. Yet, in design and performance, this standard remains unique — truly, one of a kind, a product of private research conducted in advance of the need.

Today, you can order this 5×10^{-10}/Day stability, for early delivery, and without incurring developmental uncertainties, costs and delays.

Write us for complete technical data.

DIMENSIONS:
7½" W × 6" H × 12½" D

The JK-SULZER FS-1100T Frequency Standard is fully transistorized. A double proportional control oven houses a 1 mc precision quartz crystal having a Q exceeding 2 million. Each unit is built, aged, and calibrated at Washington, D. C. against groundwave signals of WWV. Simultaneous outputs at 1.0 mc and 100 kc. A companion power supply permits operation from 115 VAC plus automatic 12 hours minimum of emergency or portable operation from batteries. A wide range of harmonic, sub-harmonic, and special frequencies available on special order.

". . . the best is yet to be."

The James Knights Company
Sandwich, Illinois

FLY THERE ON
UNITED AIR LINES!

Institute of Radio Engineers Convention New York, March 21 - 24

United Air Lines serves the Convention Route of the Nation—with convenient day and night Mainliner® schedules between 80 major cities coast to coast, and to Hawaii. Service includes new DC-8 Jet Mainliner—the *best of the jets*. And, of course, United Air Lines famous *extra care* attends you all the way. So make sure you don't miss out on this year's convention—fly there on United. For reservations, see your travel agent or call your local United Air Lines office.

UNITED AIR LINES® DC-8
JET MAINLINER, BY DOUGLAS

THE
BEST
OF
THE
JETS...
PLUS
UNITED'S
EXTRA
CARE

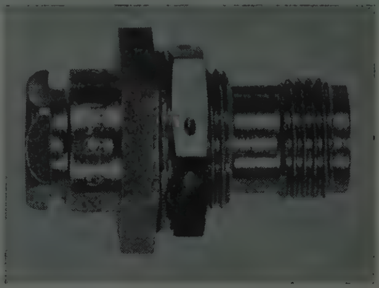
Whom and What to See at the Radio Engineering Show

(Continued from page 304A)

Kings Electronics Co., Inc.

40 Marbledale Rd.
Tuckahoe 7, N.Y.
Booths 2821-2823

G. Alterman, ▲ S. Jackson, ▲ G. Nuremberg, ▲ M. Weissman, A. Ferrari, ▲ D. Davis



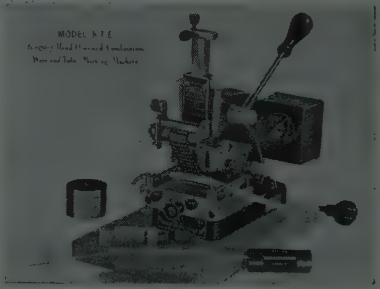
Individually Calibrated Connector

Exhibit will be a line of Foamflex and TNC connectors with extraordinary VSWR readings individually calibrated for Specific or Broad Band use.

Kingsley Machine Company

850 Cahuenga Blvd.
Hollywood 38, Calif.
Booth 4235

George E. Kingsley, A. C. Sheffield, Norman Friedman



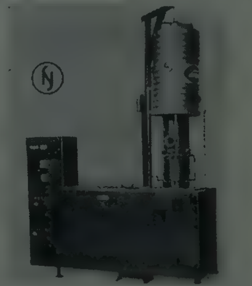
Hand Operated Wire Marking Machine

Wire marking machines for placing wiring diagram circuit references on the outer covering of insulated wires and cables. Equipment for production of wire identification markers. Electric ovens for continuous sintering of markings on Teflon TFE insulated wires and tubing.

Kinney Vacuum Division

The New York Air Brake Company
3529 Washington St.
Boston 30, Mass.
Booths 4309-4311

W. B. Mills, J. P. G. Davis, W. G. Small, S. MacKiernan, J. A. Brower, A. W. Livesey, G. Brewer, J. Leonetti, A. M. Messina, R. Denton, W. Crowley, J. Donahue



Ultra High Vacuum Production Units, Floating Zone Refiner, Packaged High Vacuum Pumping System, Complete Evaporator Equipment, Special Electronic Depositors, High Vacuum Pumps, High Vacuum Components. ULTEK Ultevac Pumps.

KinTel

Division of Cohu Electronics, Inc.
5725 Kearny Villa Rd.
San Diego 12, Calif.
Booths 3613-3617

Henry Pannell, ▲ Joe Szewzuk, ▲ Earl Cunningham, ▲ Chek Titcomb, Al Braun, Jack JaQuay, ▲ Bill Ivans, Bill Royce

Model 601A AC Voltage Standard

DC digital voltmeters, AC converters, militarized AC/DC digital voltmeters, multi-channel scanners, AC and AC/DC digital voltmeter preamplifiers, digital ratiometers, differential DC amplifiers, wideband DC amplifiers, AC voltage standards, DC voltage standards, electronic galvanometers, closed-circuit television systems.

Kintronic Division, Booth M-23
See: Chicago Aerial Industries, Inc.

Knapic Electro-Physics, Inc.

936-38 Industrial Ave.
Palo Alto, Calif.
Booth 2003

Dr. Dean D. Knapic, George M. MacLeod, Gustav Bard, Harvey Court, Philip Wexler, Michael Kaufman

Silicon and Germanium Monocrystals in all sizes and resistivities for semiconductor use. Large Diameter Grown Ingots to eight inches for Infrared Dome and Lens application.

Knight Electronics Corporation, Booths 3915-3917
210 S. Des Plaines
Chicago 6, Ill.

▲ M. Bond, L. M. Dezettel, O. Fried, J. Korshak, ▲ G. Mills, L. S. Preskill

Professional quality electronic kits, Hi-Fi and Stereo components, test instruments, amateur gear. All specifications unconditionally guaranteed. Amplifiers, tuners, scopes, communications receivers, intercom, VTVM, portable radios, tube testers. Exclusive features for faster, easier building.

James Knights Co.

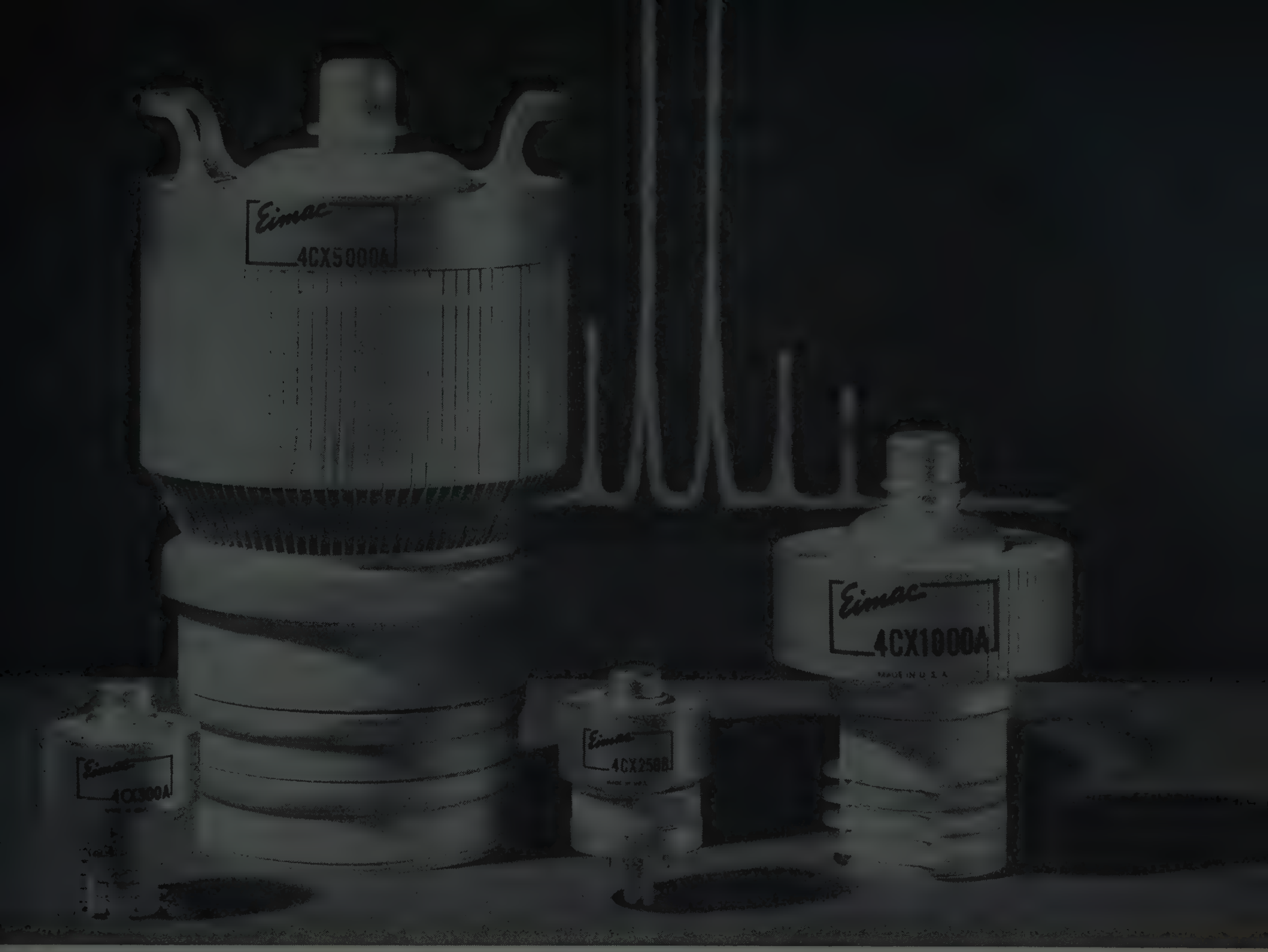
101 East Church St.
Sandwich, Ill.
Booth 2708

▲ John F. Silver, Glenn Munro, Louis A. Dick, W. R. Doede, ▲ Robert B. Beetham

Precision quartz crystals in conventional and "Glasline" holders. Precision ovens and crystal using assemblies, including crystal filters and complete miniature transistorized crystal controlled oscillators.

(Continued on page 308A)

Be sure to see all four floors!



The Ideal Approach to SSB . . .

Eimac Ceramic Tetrodes from 325 to 11,000 watts

Generating a clean SSB signal is one thing . . . amplifying it to the desired power level with stability and low distortion is another. A modern Class AB_1 final amplifier designed around an Eimac ceramic-metal tetrode is the ideal answer to the problem. The Eimac ceramic linear amplifier tubes shown above—the 4CX250B, the 4CX300A, the 4CX1000A and the 4CX5000A—offer the high power gain, low distortion and high stability that is needed for Class AB_1 operation. Each has performance-proved reserve ability to handle the high peak powers encountered in SSB operation. Efficient integral-finned anode cooler and Eimac Air System Sockets keep blower requirements at a minimum and allow compact equipment design. And, all four incorporate the many advantages of Eimac ceramic-metal design, which assures compact, rugged, high performance tubes.

The high performance and reliability of Eimac ceramic tetrodes make them the logical starting point in the design of compact, efficient single sideband equipment.

Write our Application Engineering Department for a copy of the technical bulletin "Single Sideband."

EITEL-McCULLOUGH, INC.
San Bruno, California

Eimac First with ceramic tubes that can take it

Eimac

CLASS AB_1 SSB OPERATION

	4CX250B	4CX300A	4CX1000A	4CX5000A
Plate Voltage	2000 v	2500 v	3000 v	7500 v
Driving Power	0 w	0 w	0 w	0 w

Whom and What to See at the Radio Engineering Show

(Continued from page 306A)

Korfund Company, Inc., Federal Division, Booth 1324
48-15 Thirty-second Pl.
Long Island City 1, N.Y.

Dr. B. K. Erdoss, Donald H. Vance, J. I. Hammond, ▲ N. Kfoury, F. Purcell, A. White, Lee Perlow, J. Feigen, F. Kirschner, R. Upton

*Vibration and Shock Isolation Systems for Gyros, Inertial Platforms, Computers, and Other Electronic Equipments; *Broad Temperature Elastomer Mount; *All-Attitude Spring Mounts; *Rotationally Constrained Mountings for Gyros; *"LO-Q" Structural Coating For Resonant Structure Problems; Shock and Vibration Proof Shipping Containers.

Krengel Manufacturing Co., Inc., Booth 4227
227 Fulton St.
New York 7, N.Y.

A. L. Gershon, George A. Feldman, John A. Collins, Jr., Howard D. Gershon, Gilbert M. Bloch, Lloyd B. Thompson, Harold Murray, Dominick Ponzo

Marking Devices; Steel Stamps; Printing Machines, Hand or Automatic; Engraved DEEP-KUT Stamps; Corporation & Notary Seals; Stencils; Daters; Electric Time Stamps; Checks & Tags; Nameplates; Inks; Pads; Numberers; Inspection Stamps; Rubber Stamps; Self Inkers; Automatic Coders.

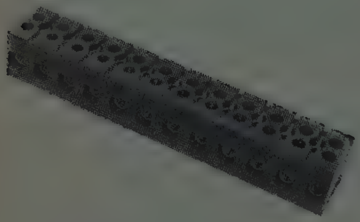
Krohn-Hite Corp., Booths 3708-3710
580 Massachusetts Ave.
Cambridge 39, Mass.

▲ George Hite, ▲ Wallace L. Bixby, ▲ Richard Haddad, ▲ John McLaughlin, ▲ Norman Riemenschneider, ▲ Vernon Hopper, ▲ Bob Meyers, ▲ Alan Stern

Ultra-high regulation tube and *transistorized power supplies; low distortion, wide-range RC oscillators; ultra-low frequency variable electronic filters; ultra-low distortion power amplifier and wide-band direct coupled 10 and 50-watt power amplifiers, with a frequency range from dc to one megacycle.

Kulka Electric Corp.
633 S. Fulton Ave.
Mt. Vernon, N.Y.
Booth 2900

▲ Eugene R. Kulka, William Kulka, Elliot Edelman



Pressure Contact Terminal Block

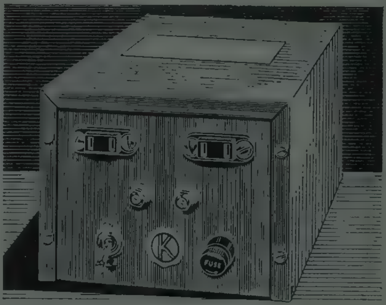
Terminal blocks, terminal strips, aircraft & electronic switches, Silicon rectifier holders, power outlets, printed circuit terminal blocks, lighting harnesses, "KLIPTITE" connectors on blocks, solder lugs, marker strips, turret type terminals on blocks, Navy type terminal boards, jumpers, spreaders, pressure-contact terminal blocks.

▲ Indicates IRE member.
* Indicates new product.

FIRST AID ROOM
First mezzanine. Take elevator 20 from north side of any floor.

Kupfrian Mfg. Corp.
395 State St.
Binghamton, N.Y.
Booth 4318

W. J. Kupfrian, C. J. Chase, F. E. Kent, W. Shaw, E. Braddock, T. Kennedy, K. M. Grout, K. L. Bitting, A. Hall

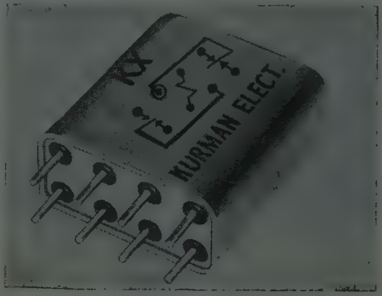


Transistorized Inverter

Stock and design-to-specification transistorized power supplies, cable harnesses, flexible shafts for remote control, and specialized hardware, including miniature Oldham couplings, universal joints.

Kurman Electric Co.
Subs. of Crescent Petroleum Corp.
191 Newel St.
Brooklyn 22, N.Y.
Booth 2134

Raphael Spiegelman, ▲ Julian Goodstein, Wallace Green, Joseph Lauria, Eric Kriegler, John Scotti, I. Cohen, R. Corenthal



Microminiature Relay

A complete and competitively priced line of relays—"off the shelf"—including hermetically sealed, sensitive, telephone, subminiature, microminiature, polar, power, antenna changeover, motor starting, RF keying, plate circuit, photo electric, open & plug in types, and dust protected.

LIECO, Inc., Booth 2435
See: Lieco, Inc.

LEL, Inc. *
380 Oak Street
Copiague, N.Y.
Booth 2102

▲ James Allsopp, ▲ Charles Baker, ▲ Charles Bissegger, ▲ Walter Hollis, ▲ William Maggio, ▲ Robert Mautner, ▲ David McPherson, ▲ Robert Murphy, ▲ Charles A. Nuebling, ▲ Jack Vigiano

*Solid state microwave mixer-preamplifier, *Transistorized command receiver, *Octave RF amplifier, *Telemetering preamplifier, *Microwave receiver, *Transistorized preamplifier.

Laboratory for Electronics, Inc.
1079 Commonwealth Ave.
Boston 15, Mass.
Booths 3819-3821

▲ Perry Pollins, Mort Simon, John N. Cullen, Irv Versoy, ▲ Jim Christian, Peter Jorrens

Stable Microwave Sources, Microwave Stability Measuring Devices, Epsiline Components, Ultrasonic Delay Lines, Magnetic Heads, and Transformers—Series 814 Ultra-Stable Microwave Oscillators, Model 5004 and 5009 Microwave Stability Testers, Series 820 Crystal-Locked Klystron Sources, Model 5012 and 5014 MTI Radar Test Sets, Model 5010 S-Band Exciter, Model 5015 Pulse Stability Tester.

Lambda Electronics Corp.
11-11 131 Street
College Point 56, N.Y.
Booths 2318-2320

▲ Lester Dubin, ▲ Simeon Weston, Merrill Simon, ▲ Benjamin Shmurak, ▲ Sol Greenburg, William Kellerman

Featuring a new line of high-current, low-voltage, solid-state power supplies. Also, a wide range of transistor-regulated and tube-regulated power supplies for production and laboratory service.

Land-Air, Inc., Booth 1600
See: Stepper Motors Corp.

Landis & Gyr, Inc.
45 West 45th St.
New York 36, N.Y.
Booth 3012

▲ M. Wiesendanger, H. A. Jenny, W. H. Goudy, W. Steinmann

SODECO Print Counter

Electro-magnetic impulse counters; electronic high-speed counters; predetermining counters & high-speed electronic predetermining counters; monodecade counters; bi-directional & bi-directional predetermining counters; printing counters & printing counters with date/time printer; add-subtract counters; hour, minute, second counters; pulse generators; instrument transformers.

Langevin Div., Booths 1204-1206
See: W. L. Maxson Corp.

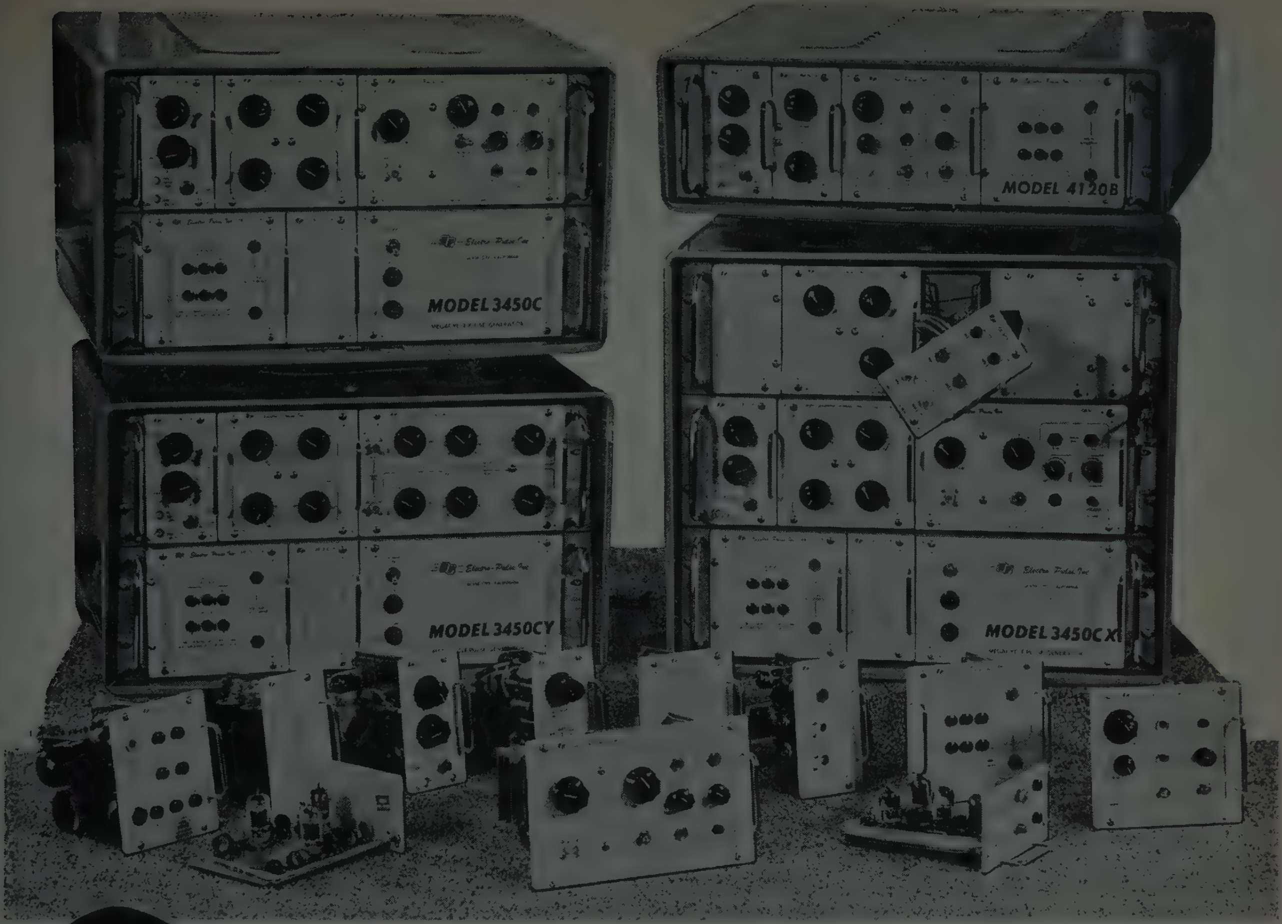
Lansdale Tube Company, Booths 1302-1308
See: Philco Corp.

LaPointe Industries Inc., Booth 2113
155 West Main St.
Rockville, Conn.

Dan Malone, Fred Wisk, Al Esten, John Sullivan, Tom Collella, Warren Anderson, Al Fargo, J. H. Stillbach

Printed Circuitry & Packaged Circuitry, Variable Capacitors, Electronic Assembly, Beryllium Components for Inertial Navigation, Small Aluminum Tubing.

(Continued on page 310A)



NOW!

FULL coverage in Pulse Instrumentation through MODULAR CONSTRUCTION

Modular plug-in construction adds unparalleled versatility and serviceability to proven EP circuit quality, allows extension of standard instruments to special requirements, and provides the key to rapid, economical fabrication of simple or complex pulse and digital instrumentation systems.

Electro-Pulse currently manufactures 137 standard pulse and digital circuit modules (both tube and transistor types). Over 90 catalog instruments are offered to save you time and money in the generation of fast-rise pulses, pulse pairs, pulse trains, gates, time delays, digital words, programmed current pulses, PPM and PCM codes, etc. Our current comprehensive catalog is yours for the asking.

Various combinations of only eleven basic pulse circuit modules,* when plugged into wired rack frames, make up the four standard pulse generators shown above—

3450C—.015 μs rise single pulses, 50v into 50 ohms to 2MC, variable durations, delay and waveform.

3450C/X—Adds pulse pair and pulse train capabilities to 3450C.

3450C/Y—Fast rise, power flip-flop (45v into 470 ohms, Pos. and Neg. outputs), duration to 1 sec., rep rate to 1.7MC.

4120B—Economical fast-rise pulses to 500KC, 35v into 100 ohms.

Write for complete data: Bulletins 3450 and 4120

*Basic modules in photo above: Time Base, Delay and Width Control, Pulse Forming, Flip-flop, Trigger Amplifier, 2 Output Amplifiers, 2 Power Regulators, Rectifier-Filter, and Gating Control, with variations. Also available: Counters, And/Or Gates, Crystal Oscillators, Precision Time Delays, Blocking Oscillators, Mixers, Inverters, Attenuators, Input Amplifiers.

Note, in above photo of 3450CX, the ease with which a single module may be extended on plug-in adapter for service.

Representatives in Major Cities

EP

Electro-Pulse, Inc.

11861 TEALE ST., CULVER CITY, CALIF. • Phone: UPton 0-9193 or EXmont 8-6764

Pulse and Digital Circuit Engineers:
Rapidly expanding Systems activity and New Product development at Electro-Pulse have created several attractive openings for qualified engineers. Please send resume to T. C. Ridgway, Personnel Manager.

CAN YOU

MEASURE JUNCTION THERMAL IMPEDANCE REPRODUCIBLY

TEST CONTROLLED RECTIFIERS DYNAMICALLY

GENERATE ONE 5000 AMP. SINUSOIDAL PULSE

EVALUATE A 500 AMP. RECTIFIER AT 1500 VOLTS

...We Can!

WA

BRING YOUR DIODES AND HEAT SINKS TO BOOTH #3006

WALLSON ASSOCIATES, INC.
912-914 Westfield Ave., Elizabeth, N. J.

Whom and What to See at the Radio Engineering Show

(Continued from page 308A)

Larson Instrument Co., Booth 3121
24 Orchard St.
Tarrytown, N.Y.

L. H. Larson, R. Asen, T. Hendel, M. Lichtenstein, G. Adam, A. Shore, C. Sargeant, F. Bowden, B. Chase, B. McCarthy

Plug-in contact meter indicating controls featuring high speed, accuracy, repeatability. Inkless 30 channel recorders featuring 3600 times magnification in 5 milliseconds, binary, digital, sequence, on-off recording.

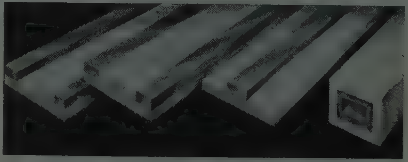
Lavoie Laboratories, Inc., Booths 3911-3913
Matawan-Freehold Rd.
Morganville, N.J.

A. P. Buckley, Robert James, ▲ Thomas Laugesen, Larry Lippert, Louis Tischler

Improved line precision instruments, designed & produced to provide highest standards of performance & reliability in spectrum analyzers, oscilloscopes, frequency standards, frequency meters, counters, specialized oscilloscope development & production for commercial & military electronic sales. *303 Automatic Impedance Checker. *LA-80 Frequency Counter.

Leach & Garner Company
Industrial Division
Leach & Garner Bldg.
Attleboro, Mass.
Booth 4052

Gerald F. Tucci, Fred Dole, Sam Greenbaum, Arthur O. Marcello, Jr., Peter Microulis, B. Hocker



Laminated and solid precious metal contact material. Alloys of gold, silver, platinum and palladium. Tubing, wire sheet; Overlay, Inlay, Toplay, Thrulay, and Edgelay. Silver and gold solders. Non-ferrous and precious metal foil strips. Waveguide tubing. Roll formed shapes.

Leesona Corporation, Booths 4323-4325
P.O. Box 1605
Providence 1, R.I.

W. T. Crocker, C. Zaikowski, I. Marsh, W. Rainford, W. Quinn, J. Halliday

Two #107 automatic coil winders equipped with space-wind, paper-miss detector, auto-slow down and other attachments being run simultaneously by one operator. One #108 semi-automatic coil winder featuring quick set up, hand-feed, paper insulating sheets.

(Continued on page 311A)

▲ Indicates IRE member.
* Indicates new product.

See all the exhibits!

Don't miss these important locations—

Mezzanine at back of first floor. South Room at center of south wall, second floor. 3000 court at southeast corner of third floor. 4000 court at southeast corner of fourth floor. 4500 court in northwest corner of fourth floor.

arra π LINE CONTINUOUSLY VARIABLE ATTENUATOR

Exclusive Features:

- Broadband Impedance Match.
- Min. VSWR for all values of attenuation over band.
- Insertion Loss: 0.2 db max.
- Calibration Accuracy: ±0.2 db.
- Drive: Micrometer for general use. Piston & Shaft drives for systems & power level applications.
- Connectors: Type "N" Female (others on request).
- Size: 5" dia. x 1" high, excluding connectors and micrometer.
- Power Rating: 10 watts average min.
- Calibration freq.: midband
- Continuously variable for all values of attenuation.

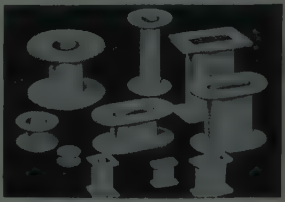
Write for Information — Dept. P-IRE

arra Antenna & Radome Research Associates
1 BOND STREET • WESTBURY, N. Y.

See us at IRE Show—Booth M-9

25 years of progress in tiny parts

GRC



SCREWS
HEX NUTS
WASHERS
INSULATORS & BUSHINGS
COIL BOBBINS
WIRE TIES
WIRE CLAMPS

NYLON COIL BOBBINS

WIDE RANGE OF STOCK SIZES —from 1/4" diam. x 11/64" long, to 11/16" diam. and 11/16" long. Round, square, rectangular to your specs. Any thermoplastic, any shape, any size. (No minimum size. Maximum to 11/16" x 11/16".)

YOU SAVE thru GRC's exclusive mass production methods—single cavity techniques—on fully automatic, patented machines. GRC's one-piece nylon molded bobbins are highly uniform-accurate. Speed winding, make the most out of nylon's outstanding properties.

When you need bobbins, you want GRC. Send for standard stock sheet or quotes on sizes, shapes, and materials to your order.

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Write now for prices and new GRC Fastener Catalog

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World's Foremost Producer of Small Die Castings
13 Second St. • New Rochelle, N.Y.
Phone: NEw Rochelle 3-8600

Whom and What to See at the Radio Engineering Show

(Continued from page 310A)

Lepel High Frequency Labs., Inc.
54-18 37th Ave.
Woodside 77, L.I., N.Y.
Booth 4236

H. Peterson, H. H. Watjen, C. L. Jennings, A. Vescuso, H. Stiefeling, E. N. Curcio, F. G. Holzhausen, J. Dietz, A. Bellini, P. Capolongo, Harry Hoffmann, G. K. Einhellinger

Model HCP-Floating Zone Fixture

High frequency induction heating equipment for semiconductor work, crystal pulling, floating zone. Model HCP floating zone unit, improved model, the first of its kind to be exhibited. Bench model for heating pretinned wires. Water recirculator.

Levinthal Electronic Products, Inc.
Subsidiary of Radiation, Inc.
Stanford Industrial Park
3180 Hanover St.
Palo Alto, Calif.
Booth 3003

▲ Eli Goldfarb, ▲ Howard Jessup, ▲ Joseph Swanson, ▲ Robert V. Johnson, ▲ Elliott Levinthal, ▲ Albert J. Morris

60 KW Klystron Transmitter, 225-400 mc

Equipment: Transmitters, modulators, power supplies, medium-high-power pulse transformers and pulse current transformers for radar, communication, tube development. Nuclear: Scintillation crystals, transducers.

Librascope Division, General Precision, Inc., Booths 1501-1503
808 Western Ave.
Glendale, California

R. E. Hastings, ▲ C. K. Krill, ▲ H. R. Davidson, ▲ H. Hemmendinger, J. K. Walker, M. C. Hirsch, G. J. Howard, P. D. Ship

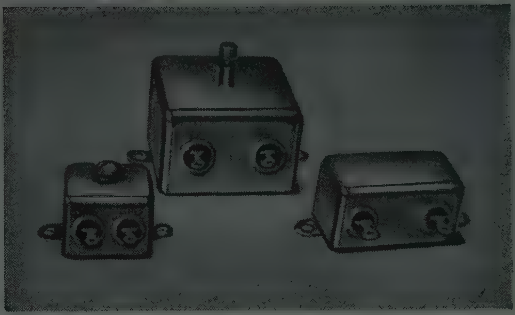
Shaft Position-To-Digital Encoders including Non-Contact Magnetic*; Contact Type with Size 8* and Size 18* Synchro-Mounting; Oil Filled*; Relay Closure*; 10 Bit Per Turn V-Scan*; 10 Bit Per Turn Self-Decoding. X-Y Plotter.

Licon Switch & Control Div., Illinois Tool Works, Booth 1506
6606 W. Dakin St.
Chicago 34, Ill.

J. B. O'Connor, J. O. Roeser, H. F. Benjamin, P. A. McCullough, N. H. McDowell

Precision Snap Action switches and related electro-mechanical devices including a complete line of basic, diecast, enclosed, impulse, subminiature and hermetically sealed units. Sealed and unsealed pushbuttons, toggles, levers, and plunger actuators are also available. Pascol Div.—Rotary D.C. solenoids, solenoid-switch assemblies.

(Continued on page 312A)



PC

Variable and close tolerance Polystyrene Capacitors

All types have power factor of less than .05% at 1000 CPS.

Type PV and Type PW variable polystyrene capacitors in bathtub containers. Highly stable and adjustable over the range of plus - minus 1% of the nominal capacitance.

Type PX close tolerance polystyrene capacitors in bathtub containers. Tolerances available 1%, 0.5%, 0.25% and 0.1%. Stability better than 0.1% per year of life.

Write for free bulletin Type PV.

Plastic Capacitors, INC.
2620 N. Clybourn Chicago 14, Illinois DI 8-3735

among the many exceptional precision devices that will merit your attention in . . .

0.0002% 0-4KC
0.0005% 4-10KC

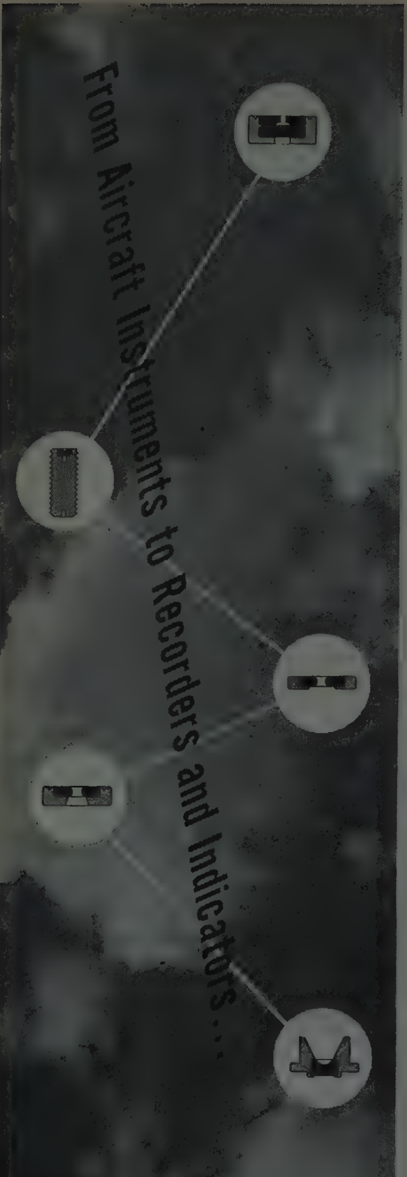
booth 3238 will be this Model VDR-106A

PRIMARY STANDARD AC and DC VOLTAGE DIVIDER

with two-part-per-million absolute accuracy, built around our unique* NB-1 Resistors for permanent stability.

JRL JULIE RESEARCH LABORATORIES, INC.
556 West 168th Street, New York 32, N. Y. LOrraine 8-8700
Ultra-Precise Resistors, Networks, and Instruments

*patent applied for


From Aircraft Instruments to Recorders and Indicators . . .

Bird PRECISION JEWEL BEARINGS *are at the heart of accurate performance*

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serving industry with fine jewels since 1913

Whom and What to See at the Radio Engineering Show

(Continued from page 311A)

Lieco, Inc.

Syosset Industrial Park
130 Eileen Way
Syosset, L.I., N.Y.
Booth 2435

A. Zeitz, M. Zanichkowsky, S. Goldstein, M. Goldstein, W. McHugh, S. Glassman, A. Cirolia, F. LeBlanc, T. Hendel

±360° Sector Scan Rotary Joint

In addition to the broadband-high power RG96/U (above), a complete line of rigid and flexible waveguide assemblies, components and test equipment with UHF waveguide assemblies available including balanced phase Aluma Flex-Guide.

Lindberg Engineering Co.

High Frequency Division
2321 W. Hubbard St.
Chicago 12, Ill.
Booth M-19

Paul Bjork

Model LA-VSE-24ZR, zone refining scanner for float zone refining silicon and other semiconductor materials and various types of furnaces applicable to the production of semiconductor devices.

Line Electric Co., Inc., Booth 1107
271 South 6th St.
Newark 3, N.J.

S. Tobol, F. C. Corbutt, G. G. Galion, C. E. Pellechio

Relays: General Purpose 5, 10, 15 ampere open and plug in; Latching 5 & 10 ampere, open and plug-in type; Thermal Time Delay; Telephone Type; Spot-lite Indicating Relays; Screw Terminal Motor Starting Relays; Footswitches; Polystyrene Housings; Buzzers, AC & DC. Coils.

Ling-Altec Electronics, Inc., Booths 3802-3804 & 3311

See: Ling Electronics, Inc., & Electron Corp.

Ling Electronics, Inc., Division Ling-Altec Electronics, Inc., Booths 3802-3804
1515 S. Manchester Ave.
Anaheim, Calif.

Cameron G. Pierce, Charles Theodore, Lew Gillingham, Stan Walters, Robert Lewis

ESD-ASD 20 Equalizer-Analyzer. Shakers, several newest models*. Rand-o-Matic console equipment and Sine-o-Matic console equipment.

Link Belt Corp., Booth M-10

See: Syntron Company

Link Division General Precision, Inc.

Hillcrest Road
Binghamton, N.Y.
Booth 1507

C. Miale, ▲ G. Herzfeld, R. Seals, J. Newell, J. Ritchie, R. Thompson

Digital Plug-In Modules, Analog Building Blocks, A/D-D/A Conversion Modules, Servo Systems Components, Servo Systems, Universal Analog Function Generator, Hi-Speed Digital Function Generator, Data Display and Presentation Systems.

Liquid Carbonic Div., Booth 3060

See: General Dynamics Corp.

Littelfuse, Inc.

1865 Miner Street
Des Plaines, Ill.
Booth 2923

J. D. Hughes, W. A. Clements, H. A. Cornelius, W. J. Henke

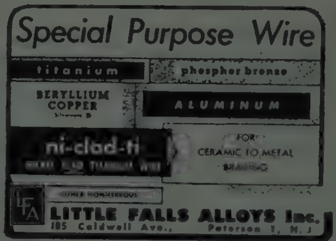
3AG Indicating Fuse Post

A New series of Indicating 3AG Fuse Posts provide instant blown fuse indication with high degree of illumination. Available across voltage range of 2½ to 250 volts. Minimum current 20 amps—and new sub-miniature Microfuses from 1/500 amp. through 5 amp. at 125 volts. Fuse measures only .205 dia. × .270 long. Precision engineered with high reliability.

Little Falls Alloys, Inc.

189 Caldwell Avenue
Paterson 1, N.J.
Booth 4015

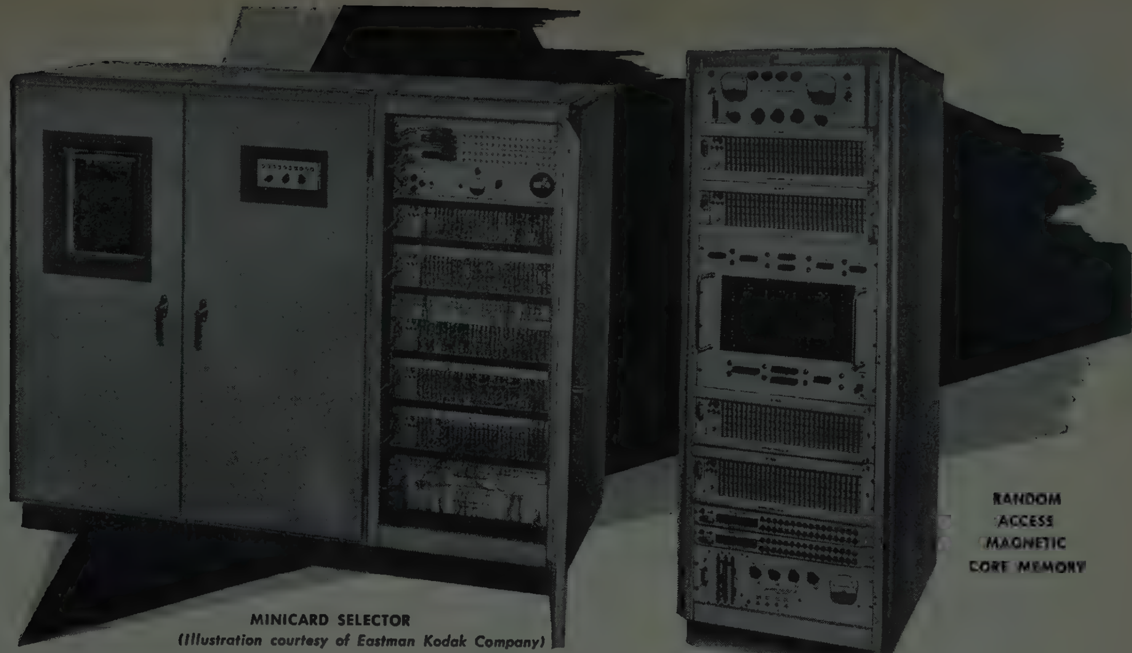
Harold M. Malm, James Sacco, O. Veltri, Peter Von der Horst



Beryllium Copper, Bronzes, Brasses, Titanium, Nickel Clad Copper, Nickel Clad Titanium, Solder coated and silverplated wire. Round, Flat, Square and Rectangular Shapes.

(Continued on page 314A)

The letter "M" preceding a booth number indicates that the exhibitor will be found on the mezzanine at the back of the first floor.



RANDOM
ACCESS
MAGNETIC
CORE MEMORY

MINICARD SELECTOR
(Illustration courtesy of Eastman Kodak Company)

3C . . .
Solves problems with Special Purpose Digital Systems

Special purpose digital systems economically provide solutions to many complex problems in comparison, guidance, decision, evaluation, information storage and retrieval, sorting, computation, and similar needs. For speed and efficiency, a digital system cannot be equalled. Two examples are:

PROBLEM: *Wanted, a machine to make decisions involved in library-type operations (sorting, sequencing, selection) on single and multi-page documents photographically recorded on Eastman Kodak Minicard Film Records. These Film Records measure 16 mm. x 32 mm. Each one can hold up to 2730 bits of binary information, or up to 12 legal size pages with 294 bits of binary information. Binary information is photoelectrically scanned at a rate of 20 cards per second and the film records are sequenced where document pages extend to two or more cards.*

SOLUTION: A 3C special purpose digital system meets all requirements. The system incorporates T-PAC (1 megacycle) dynamic digital modules and magnetostrictive delay line serial memories. The manner and use of the 'question' material to select, sort and sequence, is determined by plugboard wiring and control panel switches. Even complex logical relationships between 'question' words and Minicard binary information (43 parallel bits per word in length) are specified on the plugboard. All operations are performed with the time-and-equipment-efficiency techniques characteristic of serial dynamic logic. In practice this system has proven highly successful.

PROBLEM: *Data-processing installation required to increase computation speed permitting on-line operation. A major portion of computation time is lost extracting roots in pressure-velocity conversions and correcting for non-linearity in other transducers.*

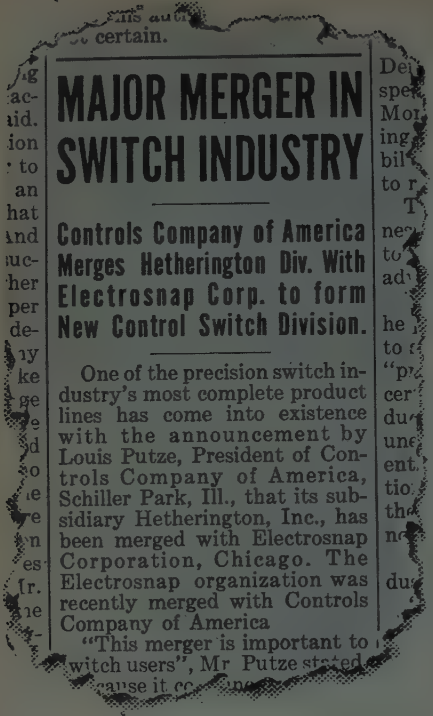
SOLUTION: 3C Modular Transistorized Random Access Magnetic Core Memory was installed to serve as a "linearizer" or table look-up. After calibration, data is stored in the memory (from magnetic or perforated tape, or other permanent source). A digital transducer signal, fed to the memory, acts as an address signal and the memory output produces the linearized signal. This allows linearization of any desired accuracy in a few microseconds, for direct use in a data reduction computer. Signals from one or several transducers can be linearized at rates well over 100,000 per second with a single 3C Memory.

SEE BOOTHS NO. 3308-3310
IRE SHOW

3C has designed and built a large number of special purpose digital systems during the last eight years. This experience is yours for the asking. Call us for consultation on your system requirements — proposals submitted on request.

COMPUTER CONTROL COMPANY, INC.

EASTERN DIVISION: 983 CONCORD ST. • FRAMINGHAM • MASSACHUSETTS
BOSTON: CEdar 5-6220 • FRAM: TRinity 5-6185 • TWX FRAM 17
WESTERN DIVISION: 2251 BARRY AVE. • LOS ANGELES 64 • CALIFORNIA
GRanite 8-0481 • BRadshaw 2-9135 • TWX W LA 6634



MAJOR MERGER IN SWITCH INDUSTRY

Controls Company of America Merges Hetherington Div. With Electrosnap Corp. to form New Control Switch Division.

One of the precision switch industry's most complete product lines has come into existence with the announcement by Louis Putze, President of Controls Company of America, Schiller Park, Ill., that its subsidiary Hetherington, Inc., has been merged with Electrosnap Corporation, Chicago. The Electrosnap organization was recently merged with Controls Company of America

"This merger is important to witch users", Mr Putze stated

WHAT'S IN IT FOR YOU?

You may now select from the industry's most versatile and complete line of precision snap-action switches, indicator lights, push-button switches, toggle switches, Switchlites, and environment-free limit switches. You can now make broader product groupings for greater quantity discounts. With this new single source, you will now deal with just one sales engineer for all your switch needs.

Three plant locations—Folcroft, Pa., Chicago, Ill., and El Segundo, Calif.—will provide regional engineering and manufacturing facilities to speed delivery and service.

Local sales offices with factory-trained personnel have been set up to provide on-the-spot application engineering in all major markets. An expanded nation-wide distributor organization will assure you of immediate delivery from local sources.

ELECTROSNAP
HETHERINGTON

CONTROL SWITCH DIVISION
CC
CONTROLS COMPANY OF AMERICA
4218 W. Lake Street • Chicago 24, Illinois
Telephone: VAn Buren 6-3100 • TWX No. CG-1400

Whom and What to See at the Radio Engineering Show

(Continued from page 312A)

Litton Industries, Inc.
336 North Foothill Road
Beverly Hills, Calif.
Booths 1610-1618, 1709-1717

Grafton P. Tanquary, ▲ Robert C. Kolts, David S. Rathje, Stuart G. Whittlesey, Robert Dolbear, David Mutchler, Beverly Kumpfer, John C. Jacobs, James W. Weidenman, Karl Clough, ▲ L. W. Howard, ▲ Ernest Clover, ▲ Edmund Shimbel, Jack T. Gentry, Richard J. Kuri, George W. Steck, Henry P. Bechtold, Jr., Leo Call, Teck A. Wilson, Jack Thorne, Merritt McKnight, Carl Tendler, George Constantine, Anthony Easton, John Shonnard, Vincent Gale, James Martin, Lawrence Truitt, Kenneth McConnell, Herbert Israel, Peter Marzan

Direct writing picture tube demonstration, computer components, shaft encoder, microwave power tubes, inertial reference elements, communications equipment, facsimile transmitting and receiving systems, airborne digital systems, potentiometers, transformers, printed circuits, ferrite isolators, related microwave components, terminals & hardware, gas noise sources, display tubes, demonstration of pulse rate modulation transmission.

Lord Manufacturing Co., Booth 2131
1635 West 12th St.
Erie 6, Pa.

M. D. Wood, J. M. Weaver, V. Ellis, G. H. Billman, J. J. Goodill, R. P. Thorn, J. P. Cooney

Unit isolators and complete mounting systems (standard and custom designed) for shock, vibration and noise control of sensitive equipment.

Lumatron Electronics, Inc.
68 Urban Avenue
Westbury, L.I., N.Y.
Booth 3059

▲ Gerrard G. Leeds, ▲ Richard S. Rothschild, ▲ Paul Schwartz, ▲ Stewart Clothier, ▲ Lee Norwood, ▲ Robert Corenthal

New Model 112 oscilloscope with .04 millimicrosecond risetime, .05/cm sweep speeds and mv sensitivity. Universal mys sampling oscilloscope attachments for display of mys pulses and wave forms up to 600 mc on conventional oscilloscopes. Mys pulse generators. Transistor and diode testers for mys switching parameters, automatic and manual.

MB Electronics, Div. Textron Electronics, Inc., Booths 3107-3109
781 Whalley Ave., P. O. Box 1825
New Haven 8, Conn.

A. C. Deichmiller, R. Bartman, Jr., J. Dudrick, J. C. Stephens

*Calibration system for velocity pickups and accelerometers, 150-lb. force, 5 to 10,000 cps frequency range—*Model N503 vibration meter accepts accelerometer or velocity pickup input, reads velocity, acceleration, or displacement—*New hydraulic shaker models cover force range from 1000 to 100,000 lbs. and stroke from 14" to 9".

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* Indicates new product.

MM Enclosures, Inc., Booth 4011
111 Bloomingdale Rd.
Hicksville, L.I., N.Y.

Michael C. Presnick, Louis J. Wepy, George Boziwick, Gilbert Bassin, Phillip Luce, Carl Berntsen, Robert Ebert, Kenneth L. Reidy, Norman Stachalek, Ernie Williams, Chester A. Milewski, Richard Sager

Electronic Instrument, Transit and Combination Cases Constructed To Conform To Military Specifications MIL-T-945, MIL-T-21200, MIL-C-4150, MIL-T-4734 and MIL-STD-108. Metal Electronic Enclosures and Housings. Custom Fabricated Precision Assemblies and Weldments.

Machlett Laboratories, Inc., Subsid. Raytheon Company, Booths 2604-2614
1063 Hope St.
Springdale, Conn.

W. Brunhart, H. D. Doolittle, D. S. Frankel, C. Kirka, R. E. Nelson, M. Rome, G. J. Taylor, C. V. Weden, A. F. Wegener, S. Yanagisawa

Electron Tubes: UHF Planar Triodes; Shielded Grid Triodes, Tetrodes & Rectifiers; TV Camera Tubes; Scan Conversion Tubes; High Power Vapor Cooled Triodes.

MacLeod & Hanopol, Inc., Booth 3711
10 Roland St.
Charlestown 29, Mass.

A. D. MacLeod, L. Hanopol

Capacitance Bridges, and Megohmmeters for Vacuum Tube Measurements.

Magnecraft Electric Co., Booth 2525
3352 West Grand Ave.
Chicago 51, Ill.

H. D. Steinback, M. S. Steinback, W. J. Gorman, J. E. Deimel

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Universal Power Control Units, Static Sequencers and Programmers, Static Inverters. Transistor-Magnetic Servo Amplifiers, Voltage/Current Regulators, Magne-Speed Drives, Phase Analyzer Transistor Curve Tracer Instruments.

(Continued on page 316A)

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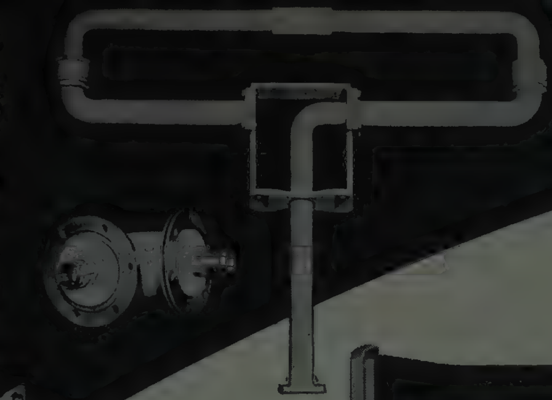

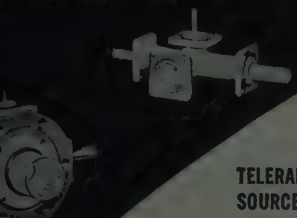

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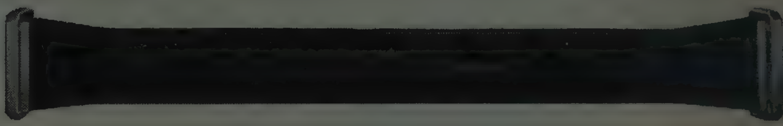
... for that difficult installation.



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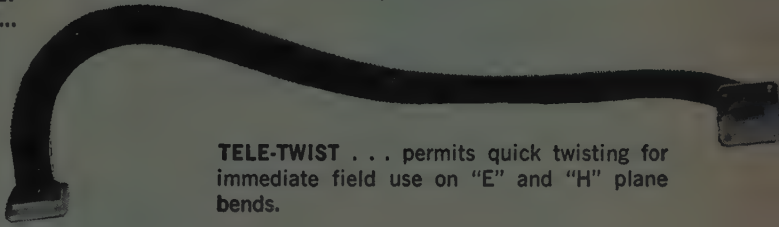
TELE-FLEX...standard moulded sections, the ideal waveguide for use where vibration mounts are not practical.



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OMPACT RADAR BEACON, designed by TELERAD offers
/Sec. receiver stability with a Receiver/Transmitter
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cy range: 2750 - 2950 MC/Sec.
cy stability: ±2 MC/Sec.
wer: 100 watts peak (min.)
petition rate: 2000 P.P. Sec.
dth: 0.65 ± 0.05 microsecond
.5 microsecond
tter: 0.1 microsecond
x 3⅝" x 7-9/16"
3.45 lbs.
upplies Available
al Order

RECEIVER
Frequency range: 2750 - 2950 MC/Sec.
Bandwidth: 6-12 MC/Sec. @ 3 DB Points
35 MC/Sec. maximum @ 40 DB Down
Triggering sensitivity: —41 DBM
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Frequency stability: ±2 MC/Sec.
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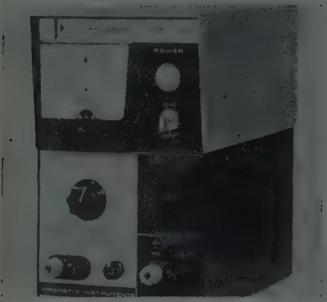
Whom and What to See at the Radio Engineering Show

(Continued from page 314A)

Magnetic Instruments Co., Inc.
Subsid. Pyrometer Co. of America, Inc.
637 Commerce St.
Thornwood, N.Y.
Booth 3017

▲ Robert Levine, Kenneth Lord, Leo Lindell, Richard Levine, Jack Metzger, Leonard Bonn



*Low Level DC Amplifier, Model 759-6

Rate of Change Computer. *New Capacitance Level Gauge. *A New and Inexpensive Low Level D.C. Amplifier. *New Low Voltage, Low Impedance Power Supply.

Magnetic Metals Co., Booth 1432
Hayes Ave. at 21st St.
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▲ H. F. Porter, ▲ D. O. Schwennesen, W. J. Miller, W. G. Pettit, H. V. Paynter, G. L. Morrow, D. O. Stanton, ▲ W. T. Mitchell, H. H. Hackett, W. Y. Hallman

Electromagnetic cores and shields; Centricores made from Super Square mu "79" will be featured. These tape wound cores are identically duplicate in all essential magnetic dimensions from unit to unit in any lot and from lot to lot without deviation.

Magnetic Shield Div., Booth 4312
See: Perfection Mica Co.

Magnetics, Inc.
Box 391
Butler, Pa.
Booth 2533

Arthur O. Black, ▲ Robert W. Olmsted, James W. Graham, H. A. Savisky, N. Altman, John T. Lee, W. S. Spring, R. C. Woodward, W. J. Irvine, J. E. Frauenheim

High permeability tape wound cores and bobbin cores. Powder cores, including 160-mu, linear, stabilized, and unstabilized. Silicon tape wound cores, cased or uncased; laminations; shields.

Magnetics, Inc., Control Div., Booth 2437
See: Control, Div. Magnetics, Inc.

Magnetics Specialties, Inc., Booth M-13
See: Nothelfer Winding Laboratories, Inc.

Magtrol, Inc., Booths 1230-1232
See: Travco Associates

D. E. Makepeace Division, Booths 2110-2118
See: Engelhard Industries, Inc.

* Indicates new product.
▲ Indicates IRE member.

P. R. Mallory & Co., Inc.
3029 E. Washington St.
Indianapolis 6, Ind.
Booths 1410-1412

Robert L. Adams, W. L. Manning, D. L. Bell, A. H. Gary, J. R. Woods, P. Hellert, F. Dasson, W. Troyer, E. F. Errico, Gordon Kane, Donald Totten, Edward Hannon, Glenn Cruze, Mike Manolios, W. C. Stafford, R. R. Forbes, William H. Booher, W. E. Lanning, W. H. Cluggish

New ½-inch Control and Other Carbon Controls; New Voltage Reference Battery and Other Battery Systems; Silicon Rectifiers; Tantalum Capacitors, Computer Grade Capacitors and Three New All-Welded Capacitors; Power Supplies, Tuning Devices, Time Delay Relays, Other Electronic Assemblies.

See also: Radio Materials Co., Booth 1414

Mansol Ceramics, Booth M-7
See: Faradyne Electronics Corp.

Manson Laboratories, Inc.
375 Fairfield Ave.
Stamford, Conn.
Booth 3213

▲ J. M. Shapiro, H. Feldman, S. Jacobson, M. Seroy

High Power Pulse Modulator (top)
Crystal Frequency Synthesizer (bottom)

*Crystal frequency synthesizers; *Highly stable oscillators and reference frequency generators, kilocycles to kilomegacyles; *Ultraprecise crystal ovens; *High power pulse modulators; *High voltage power supplies; *Microwave communications systems; *High level UHF transmitters; *Custom pulse transformers.

Marconi Instruments
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Englewood, N.J.
Booths 3301-3305

R. J. Bailey, ▲ W. A. Buck, ▲ S. E. Ellam, ▲ J. L. Garthwaite, B. E. Morris, ▲ W. Oliver

20-300 Mc/S Oscillator

Precision Capacity Bridge, *VHF Impedance Bridge, *FM Signal Generator for Mobile Radio, *Tunable Communications Receiver with crystal stability, *SSB Transmission Test Set, *Signal Generators AM/FM, Precision Deviation Meters, Noise Loading Test Set, Double-Pulse Generator, Oscilloscopes.

Marion Electrical Instrument Div., Booth 2202
See: Minneapolis-Honeywell

Markem Machine Co., Booths 4210-4212
150 Congress St.
Keene, N. H.

John G. Powers, Bernard E. Toomey, A. J. Marshala, Joseph H. Lyon, John E. Kelen, Harold B. Lampman, Gilmore G. Fretz, Roland Benson, George E. Fraser, Jr., William B. Morgan

*New miniature JAN diode printer—*small motorized offset printer—*U-1026 semi-automatic transistor side wall printer—122A automatic printer for top and side wall with latest features; 69AC color bander up to 6 colors simultaneously on diodes, resistors and capacitors.

Martin Co.
Baltimore 3, Md.

Booths 3919-3921

Peter Roche

Electronic Systems for Air Defense, ASW, Reconnaissance, Guidance, Control, Communications, Support Equipment.

Massa Labs., Div. Cohu Electronics, Inc., Booth 3609-3611
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Hingham, Mass.

▲ Ernest Massa, Kevin Corbett, ▲ Frank Massa, Jr., Jack Hubbard, Tom Pickett

Portable Recorders, Multichannel Recording Systems, Amplifiers, Sound Pressure Microphones, Accelerometers, Hydrophones, Vibration Exciters, Ultrasonic Transducers, Depth Finding Transducers, BSA-250 Recording System*, BSA-650 Recording System*, BSA-850 Recording System*.

Master Specialties Co., Booth M-16
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Los Angeles 59, Calif.

Al Franklin, Herman Jones, Chuck Sloane, Gene Burroughs, Howard Siegel

Roto-Tellite, Word Indicator Lights, Roto-Tellite Switch Lights, Time Delay Relays, Phase Sequence Relays and Flashers.

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Potentiometers, precision, wirewound, ½" to 3", linear and non-linear, high temperature, hermetically sealed. Custom designed to special function, or choose from established standard line. Precision rotary switches and various electro-mechanical devices designed to order.

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Booths 1204-1206

▲ Judd Blass, Theodore Boxer, ▲ Charles Schmidt, ▲ Harold Levenstein, ▲ Murray Simpson, ▲ Joseph Stehn, ▲ Eugene Cronin, Anthony Pignoni, ▲ Nathaniel Hughes, ▲ R. Scott Inglis

Development and manufacture of Air Height Surveillance Radar equipment; microwave antenna components; microwave phase shifters; receivers and I-F amplifiers; electronic scanning radar systems; fuzes; safety and arming devices; analogue computer components and systems; mapping and navigational radar.

W. L. Maxson Corp., Unimax Switch Div., Booths 1204-1206
See: Unimax Switch Div.

(Continued on page 318A)

FIRST AID ROOM
First mezzanine. Take elevator 20 from north side of any floor.

LEADS THE INDUSTRY IN ULTRA-HIGH-POWER DUPLEXING

with both GAS DISCHARGE and FERRITE DUPLEXERS

Selecting a duplexer for high power applications involves consideration of peak power, average power, transmit loss, receive loss, expected life, and versatility of operation.

All Microwave Associates high power gas duplexers utilize special window structures for optimum switching efficiency without sacrifice in low-level loss characteristics. These windows insure reliable, long-life performance. Both our gas and ferrite duplexers may be operated over very broad bandwidths at the common microwave frequencies.

Exceptionally complete ultra-high-power design and test equipment is utilized by our Research and Production Departments. Each duplexer is fully tested at maximum rated power before shipment.

We have extensive experience in designing and manufacturing high-power duplexer devices and are interested in working on newest ultra-high-power applications. We are now developing ultra-high-power duplexers for more efficient switching at UHF, L, C, and S bands.

Our Applications Engineers would like to discuss the future of high power duplexing with you.

Frequency Band	Duplexer Type	Peak Power	Average Power	Transmit Loss (max.)	*Receive Loss (max.)	Bandwidth
UHF	Gas	5 Mw	300 Kw	0.1 db	0.4 db	Tunable
	Gas	25 Mw	75 Kw	0.1 db	0.4 db	10% Nominal
L	Gas	25 Mw	50 Kw	0.1 db	0.5 db	
S	Gas	6 Mw	30 Kw	0.1 db	0.7 db	
	Ferrite	3 Mw	5 Kw	0.5 db	0.9 db	
C	Gas	5 Mw	5 Kw	0.1 db	0.7 db	
	Ferrite	5 Mw	7.5 Kw	0.3 db	0.8 db	
X	Gas	500 Kw	500 W	0.2 db	1.0 db	
	Ferrite	1 Mw	1 Kw	0.3 db	0.9 db	
Ku	Gas	150 Kw	150 W	0.2 db	1.0 db	
	Ferrite	150 Kw	150 W	0.3 db	0.9 db	
Ka	Ferrite	75 Kw	75 W	0.3 db	1.1 db	4% Nominal

All Microwave Associates duplexers incorporate low-loss, long-life, receiver protectors which guarantee crystal protection over wide temperature ranges and under extreme environmental conditions.

*The duplexer receiver loss includes the loss due to receiver protector TR tubes.

At each frequency band of the microwave spectrum, Microwave Associates has devices for efficient switching of high power.

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Whom and What to See at the Radio Engineering Show

(Continued from page 316A)

McCoy Electronics Co.
Mt. Holly Springs, Pa.
Booth 2311

Luther W. McCoy, David B. Jacoby, George K. Bistline, Jr., Edward P. Boise, John A. Sward, Donald E. Kutz

Precision built quartz crystal units, hermetically sealed in metal or *all glass** holders; bandpass and single sideband crystal filters, crystal discriminators, crystal ovens, and switching assemblies.

McDowell Electronics Inc., Booth 4128
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RF Induction Heating Equipment. Variable Speed Turntable*. RF Current & Voltage Measurement Equipment*. Glass to Glass Sealing Equipment*.

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See: Bussmann Mfg., Div., T. A. Edison Industries, Measurements Div.

McGraw-Hill Book Co., Inc.
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New York 36, N.Y.

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Scientific and Technical Book Publishers in the fields of electronics, nucleonics, and control engineering.

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Production engineering is rapidly becoming one of the most important facets of the radio-electronic industry. Fourth floor exhibits are devoted to this subject. On the fourth floor, you can find new machinery and tooling techniques, and discover ways to make your own product better, cheaper and faster. Don't pass up this opportunity to acquire new methods and knowledge on that all-important aspect of electronics—

PRODUCTION—FOURTH FLOOR

QUARTZ CLOCK
TYPE B-288

Description

The B-288 quartz clock consists of 6 standard units mounted on slides in a case of painted non-corrosive metal. It is very solidly built and is designed to give direct access to all parts of the quartz clock. For maintenance purposes, any unit can be replaced in less than one minute.

An emergency power supply can be added; it is also mounted in a case of painted non-corrosive metal and is entirely independent of the clock itself.

The 6 units are connected as shown in the diagram given below. They contain the following elements.

1. Power supply and synchronous clock
2. Phase-shifter, 50 c/s
3. Oscillator, 100 kc/s
4. Frequency divider, from 100 kc/s to 1 kc/s
5. Frequency divider, from 1 kc/s to 50 c/s
6. Frequency-converter, 200 c/s to 60 c/s

Uses

The complete equipment of the B-288 quartz clock opens up a very wide field of applications, such as:

1. **A high precision chronometer**, with rate variations of less than 1/100 sec. per day. It is useful for measuring and testing very short periods of time as well as for timekeeping over long periods.

2. **A permanent timekeeper**, for, fitted with the emergency power supply, the clock is unaffected by accidental variations or temporary breakdowns in the mains supply. It can therefore be used to govern a master clock distributing the exact time.

3. **A frequency standard** which is easily transportable yet extremely reliable. The standard frequencies of 100 kc/s, 10 kc/s, 1 kc/s, 200 c/s, 60 c/s and 50 c/s can be distributed throughout a building without intermediate amplification.

Thanks to the very high phase-stability, the accuracy of the 50 and 60 c/s outputs is as good as that of the 100 kc/s, oscillator. The 60 and 50 c/s signals and the impulses given each second can control precision devices used in industry, scientific research, navigation and the army.

4. **An industrial timekeeper** which can be used in watch- and clockmaking to synchronise apparatus for testing the instantaneous rate of time-pieces or to control seconds-timers.

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Empire State Building • 350 Fifth Avenue • New York 1, N. Y.
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New York 36, N.Y.
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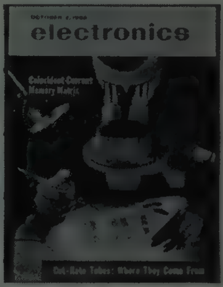

Electronics—published weekly for more than 52,000 research, design, production and management people to provide editorial coverage in engineering, design, production, use, business statistics, markets, news of component parts, accessories, equipment, circuits, and complete systems. *Electronics* Buyers' Guide—published annually.

McLean Engineering Labs.
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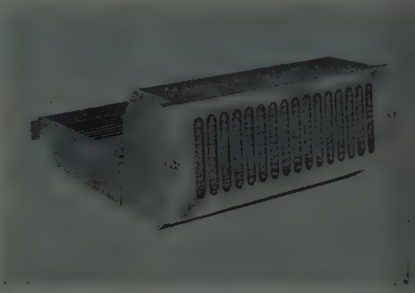
Princeton, N.J.
Booth 1624

Wallace W. McLean, ▲ W. Benjamin Eckenhoff, ▲ James G. Robinson, A. Donald Hay



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Cooling devices for electronics and missiles.

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All Steel Prefabricated Microwave Free Space Room

Airport ramp testing hoods for aircraft radar—Microwave absorbing accessories for antenna installation—Radiation attenuating linings for shielded or free space rooms—*Power line radio interference filters—VHF-UHF Microwave anechoic test chambers—Microwave testing interferometers, and thickness gages.

(Continued on page 320A)

NEW FOR FAST, ACCURATE, CONVENIENT FREQUENCY MEASUREMENTS

SPERRY *Microline*® DIRECT READING FREQUENCY METERS

Sperry has now developed a new family of Direct Reading Frequency Meters. These new instruments, covering the S, C, X, U, and K bands, provide the ultimate in convenient frequency measurements while still maintaining the accuracy necessary for most applications.

These frequency meters use a revolutionary steel tape drive for fast, accurate reading; misinterpretation is eliminated since only a small segment of the readout tape appears under the window at any given setting.

Model No.	Frequency Range (Kmc)	Absolute Accuracy	Reaction Type Q	Scale Length (in.)	Smallest Scale Division (Mc)	Price
12S1	2.60-3.95	.08%	12,000	82	1	$450
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12X1	8.2-12.4	.08%	8000	80	5	$150
12U1	12.4-18.0	.1 %	7000	81	10	$210
12K1	18.0-26.5	.1 %	6000	113	5	$220

AT THE NEW YORK IRE SHOW

See these new direct reading instruments, along with Sperry's complete line of high precision micrometer frequency meters. We'll be looking for you at Booths 2432 to 2438.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY, CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORATION

Whom and What to See at the Radio Engineering Show

(Continued from page 318A)

Measurements

A McGraw-Edison Division
P.O. Box 180
Boonton, N.J.

Booths 3501-3503

▲ Harry W. Houck, Walter B. Manson, Jr., C. Edwin Williams, Albert B. Eldridge, ▲ Norman W. Gaw, Jr.

Standard Signal Generators, Transistor Testers, Frequency Meters, Pulse Generators, Square Wave Generators, Television Signal Generators, UHF Radio Noise & Field Strength Meters, Megohm Meters, Peak Voltmeters, R.F. Attenuators, Crystal Calibrators, Intermodulation Meters, Megacycle Meters, Inductance Bridges, Capacitance Bridges, Vacuum Tube Voltmeters, Special Test Instruments.

Mechatrol Div. of Servomechanisms, Inc., Booth 2812

See: Servomechanisms, Inc., Mechatrol Div.

Adolf Meller Company

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P.O. Box 702
Providence 1, R.I.

Booth 4040

Max E. Meller, Robert Meller, Henry Hamburger, Theodore Zimmer, Anthony Ricci

Sapphire Windows, Domes, Lenses, Rods, Tubes, Spacers. Windows for Infrared and Ultraviolet Analysers, Detectors and Electronic Systems. Also, Especially Suitable for Klystron, Magnetron and T R Tubes. Various Optical Applications and Special Requirements to Customers Specifications. Tubes for Infrared and Ultraviolet Lamps.

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Don't miss these important locations—

Mezzanine at back of first floor, South Room at center of south wall, second floor. 3000 court at southeast corner of third floor. 4000 court at southeast corner of fourth floor. 4500 court in northwest corner of fourth floor.

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Booth 3843

▲ Harold W. Harrison, ▲ John B. Pettegrew, Frank Abel

Traveling Wave Tube Amplifier

Medium power broadband microwave amplifiers. Low noise broadband receivers and microwave oscillators. These units are available to cover the range 0.5 to 18.0 KMC in six frequency bands. Both solenoid and permanent magnet focused units are available for the low and medium power broadband amplifiers.

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Booths 2802-2804

L. Kirby, Jr., E. L. Beaudry, Jr., J. E. Mervin, ▲ R. Gebhardt, C. Miller, ▲ C. Engert, W. Randolph, J. Feller, R. Halpin, N. Delker

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Manufacturer of Accurate and High Stability Wirewound and Film Resistors, Wirewound, Carbon Film, Metal Film, Meter Multipliers, Power Resistors, and Custom Resistor Networks.

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All forms of Merck Ultra Pure Silicon including float zone refined doped single crystals in various diameters and *new lengths; vapor deposited Single Crystalline Silicon layers of different types and resistivities; III—V compounds; and thermoelectric material.

▲ Indicates IRE member.
* Indicates new product.

Metal Fabricators Corp., Booth 4528

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Custom designed and manufactured metal fabrications for the electronic industry. Consoles, cabinets, panels, and chassis engineered and designed to Military Specifications. Precision, close tolerance work. Certified welding. Accurate test and inspection facilities.

Metals & Controls Division, Texas Instruments Incorporated, Booths 1409-1421

See: Texas Instruments Incorporated, Metals & Controls Division

Methode Manufacturing Corp., Booth M-3

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Chicago 31, Ill.

W. J. McGinley, W. T. Jensen, W. E. Stubbings, A. D. Weiss, J. N. Barrett

Connectors—Miniature AN Per MIL-C-26500, "RELI-ACON" Printed Circuit Card Receptacles Per MIL-C-21097, Rack and Panel Connectors with Closed Entry Contacts. Custom Printed Circuitry for Military and Commercial Applications. "PLYO-DUCT" Flexible Wiring. Tube Sockets and Tube Shields for Standard and Printed Wiring Applications.

Metronix, Inc., Booths 3916-3918

See: Assembly Products, Inc.

Micamold Electronics Mfg. Corp., Div. General Instrument Corp., Booths 1218-1224

65 Gouverneur St.
Newark 4, N.J.

▲ E. Geoghegan, A. DiGiacomo, F. Senft, M. Lissner, C. Feinsot, J. Imperial, W. Pelliccia, B. Kohl, ▲ I. Clarke, A. S. Gartner, S. Solomon

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Micro Gee Products, Inc., Booth 3846

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▲ B. W. McFadden, ▲ Walter E. Peterson, David S. York

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Micro Switch Div., Booths 2204-2206

See: Minneapolis-Honeywell

Microdot, Inc.

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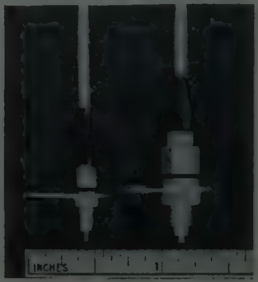
South Pasadena, Calif.

Booths 2101-2103

▲ Guy M. Martin, Jr., Robert S. Dickerman, Forrest Besocke, Philip Steward, Edith Lurie, Barry Tunick, Maureen Rainen



Micro-miniature & ultra-miniature coaxial connectors

Micro-miniature coaxial connectors and cables, assemblies; ultra-miniature connectors; low noise "mini-noise" cable; miniature coaxial SPDT switch*; custom designed transformers*.

(Continued on page 322A)

A NEW CONCEPT IN THE PRODUCTION OF SEMICONDUCTORS!

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Show, Booth No 4134

Hospitality Suite, the Manhattan Hotel

TYPE	SIZE	CAPACITANCE (uuf)	DCVW	TC	MAX. CASE SIZE
CY uuf for uuf, the smallest, most stable axial lead capacitor you can buy. Probably ⅓ smaller than you're used to. After load life tests at 125° with 150% of rated voltage, average change in capacitance is less than 0.4% for 1,000 hrs., less than 0.6% for 10,000 hrs. They exceed all requirements of MIL-C-11272A.	CY10	1 to 150 151 to 240	500 300	140±25ppm/° C. from −55° C. to +125° C. at 100 kc or 1 mc	11/32 x 11/64 x 5/64
	CY15	151 to 510 511 to 1,200	500 300		15/32 x 17/64 x 7/64
	CY20	511 to 3,300 3,301 to 5,100	500 300		47/64 x 27/64 x 9/64
	CY30	3,301 to 6,200 6,201 to 10,000	500 300		49/64 x 3/4 x 9/64
Medium-power transmitting style	CY60	Up to 56,000	Ratings to 4000 peak volts	140±25ppm/° C. from −55° C. to +125° C. at 100 kc or 1 mc	1 x 1 1/8 x 5/8
	CY70	Up to 150,000	Ratings to 6000 peak volts		1 1/2 x 1 3/4 x 3/4
CYF **Fusion sealed.** Similar to CY, but with glass encapsulation fusion sealed to capacitor and leads to make seal tight against moisture and corrosives. Insures reliable performance under extreme environmental conditions. Guaranteed four times better than MIL specs for moisture resistance.	CYF10	1 to 150 151 to 240	500 300	140±25ppm/° C. from −55° C. to +125° C. at 100 kc or 1 mc	11/32 x 11/64 x 5/64
	CYF15	151 to 510 511 to 1,200	500 300		15/32 x 17/64 x 7/64
W,WL Wafers with or without leads. Smallest high stability capacitor available. Up to 10,000 uuf in .061 sq. in. of PCB area. Electrodes sealed to dielectric sheets in such a way that seal cannot be broken without destroying capacitor. Meets the performance requirements of MIL-C-11272A.	W, WL5	1 to 560	300	140±25ppm/° C. from −55° C. to +125° C. at 100 kc or 1 mc	.281 x .218 x .090
	W, WL4	561 to 1,000	300		.281 x .312 x .090
	W, WL3	1,001 to 2,700	300		.531 x .312 x .090
	W, WL2	2,701 to 4,300	300		.531 x .453 x .090
	W, WL1	4,301 to 10,000	300		.531 x .812 x .090
HT **High temperature** dielectric and radiation-tolerant metal electrodes with tab leads. Dielectric strength is twice rated voltage applied from one to five seconds. Insulation resistance in ohm x farads is 100 at 175° C., 25 at 250° C., 1 at 300° C., and .05 at 350° C.	HT1	1 to 1,000	300	0-250° C. 115±25	1/2 x 3/8 x 3/16
	HT2	1,001 to 3,000	300	0-300° C. 140±35	1/2 x 5/8 x 3/16
	HT3	3,001 to 10,000	300	0-350° C. 160±45	1/2 x 1 x 3/16

Why you have to smash these Corning capacitors to affect their reliability

Stack alternating layers of glass ribbon and aluminum foil, fuse the stacks under heat and pressure, and you have a solid, practically indestructible capacitor.

The properties of the capacitor are *entirely* those of the closely controlled dielectric. They cannot be altered in processing. They stay the same under heat, moisture, and all other environmental conditions.

There's no problem with delivery. We mass produce them all.

If you need capacitors high in reliability, small in size, and light in weight, you should know more about this Corning design. The coupon will bring you complete technical data. Address: Corning Glass Works, 542 High St., Bradford, Pa.

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CORNING GLASS WORKS, BRADFORD, PA.

Please send data sheets on ☐ CY ☐ CYF ☐ W, WL ☐ HT
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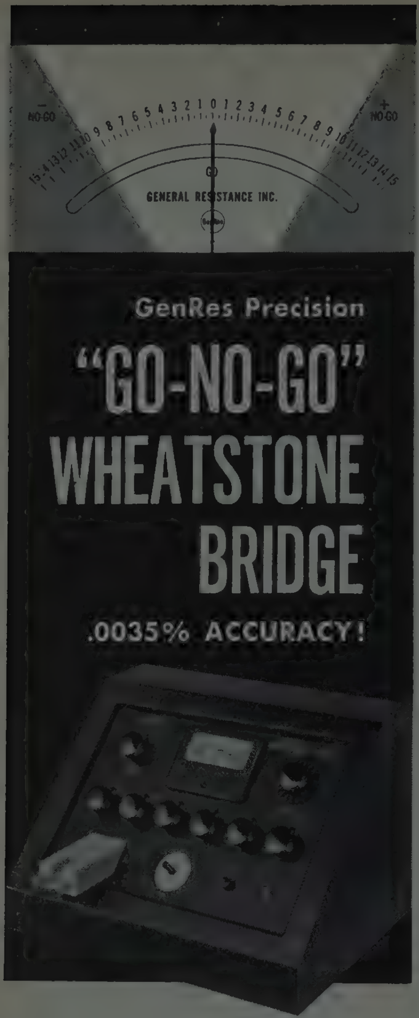
Company ....
Address ....
City .... Zone .... State ....



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"GO-NO-GO" WHEATSTONE BRIDGE
.0035% ACCURACY!

✓ .0005% SENSITIVITY
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✓ POWER SUPPLY AND DETECTOR INCLUDED
✓ UP TO ±.01% FOR FULL SCALE DEFLECTION

Operates as Go-No-Go Limit Bridge from 100 to 11,111,100 ohms with *full scale* tolerance selection of 0.01, 0.02, 0.05, 0.1, 0.25, 0.5, 1.0, 5.0, and 10%. Wheatstone Bridge from 1 ohm to 111 megohms. *Write for Bulletin P-100.*

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Whom and What to See at the Radio Engineering Show

(Continued from page 320A)

Micromech Mfg. Corp.
Div. of Sanford Mfg. Corp.
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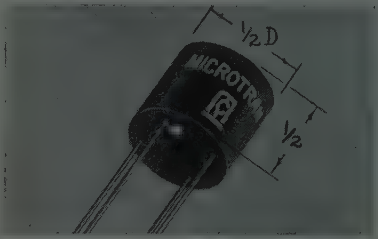
Union, N.J.
Booth 4038

R. E. Tucker, E. F. Shine, John Santillo

Advanced design Micro-Matic Precision Wafering Machines with the new *Roton Table Drive, Micromech Diamond Wheels, Semiconductor crystal holding and Orientation Fixtures, Optical Orientation systems, and the revolutionary new Micromech *"Performeter" (Diamond wheel performance indicator).

Microtran Co., Inc.
145 E. Mineola Ave.
Valley Stream, L.I., N.Y.
Booth 2315

▲ Albert J. Eisenberg, ▲ Harold Edelstein, ▲ Richard Chaber, Walter Benscher



Miniature transistor transformers consisting of ultra-miniature, subminiature low level chopper, input, DC-DC converter, silicon rectifier, power supply, transistor output, driver, powers, chokes, military and industrial calibre. Custom designed transformers and full line of miniatures stocked at franchised distributors.

One registration entitles you to permanent entry to the show for all four days. Be sure to keep your identification badge or pocket card and bring it with you when you return. Registration is not transferable.

Microwave Associates, Inc.
Northwest Industrial Park
Burlington, Mass.
Booths 2301-2303

▲ Dana W. Atchley, Jr., George S. Kariotis, Richard Dibona, ▲ Eric Stromsted, Robert J. Allen

X-Band Tunable Magnetron, MA-219

TR, ATR, PRE-TR and Receiver Protector Tubes, Ferrite Isolators, Circulators, and Complete Ferrite Duplexers. Microwave Mixer and Video Diodes; *New High Voltage Varactors and *New "Pill" Varactors; Computer Diodes; Microwave Limiters and Switches (Coax). Waveguide Components (Including *New Frequency Multipliers) X-K-Band.

Microwave Development Labs., Inc.
92 Broad St.
Wellesley 57, Mass.
Booth 2407

▲ Dr. Henry J. Riblet, ▲ Nathaniel Tucker, ▲ James R. Corcoran, ▲ Kenneth D. Jeffries, ▲ Edward Salzburg, ▲ John D. Hall

Broad Band Balanced Mixer

Research, Development, and Manufacture of Microwave Components and Assemblies, including Adapters, Attenuators, Bends, Fixed Tuned Detent Cavities, Couplers, Crystal Holders, Diplexers, Duplexers, Flanges, Filters, Generators, Hybrids, Balanced Mixers, Monopulses, Rotary Joints, T's, Ferrite Circulators, Tuners, and Phase Shifters.

▲ Indicates IRE member.
* Indicates new product.

Now ONE Machine does the WHOLE job

. . . Toroidally winds #50-#16 AWG and down to .065" fin. I.D.
DIRECTLY to desired inductance!
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ESsex 4-9800

Microwave Electronic Tube Co., Inc., Booth 2008
76 Lafayette St.
Salem, Mass.

▲ Richard J. Broderick, Harold F. McEnness, ▲ Harold Heins, Philip A. Bagnell, ▲ Louis W. Roberts, Milton R. Hamilton

Development and manufacture of Microwave Duplexing Tubes and Devices—Gas Switching, TR and ATR tubes, Magnetrons, Klystrons, Waveguide Components, Spark Gaps, Pressurizing Windows, Complete Duplexing Assemblies.

Mid-Century Instrumatic Corp., Booths 3837-3839

See: Computer Systems, Inc.

Mid-Eastern Electronics, Inc., Booth 1009
32 Commerce St.
Springfield, N.J.

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Military Systems Design, Booth 4307

See: Instruments Publishing Co., Inc.

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▲ James Millen, ▲ E. E. Williams, ▲ R. Wade Caywood, Owen I. Haszard, Philip A. Eyrick

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P.O. Box 997
Schenectady 3, N.Y.
Booth 3607

▲ Dr. W. K. Volkers, Mrs. D. J. Volkers, Imek Metzger, Donald P. Morey

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World's first ultra-low-noise amplifier which combines high input impedance (10 meg) with "hushed transistor" operation less than 0.5 microvolts).—Low-drift choppers.—Linear scale ohmmeters and bridges.—Sensitive VTVM-s.

(Continued on page 324A)

the fastest oscilloscope
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fastest rise time of all sampling oscilloscopes — 0.4 mμs rise time
fastest sweep speeds — 0.05 mμs/cm
fastest rep rates — to 300 mc w. model 603 trigger unit
and
highest sensitivity — up to 2.5 mv/cm (30:1 SNR at full scale deflection)
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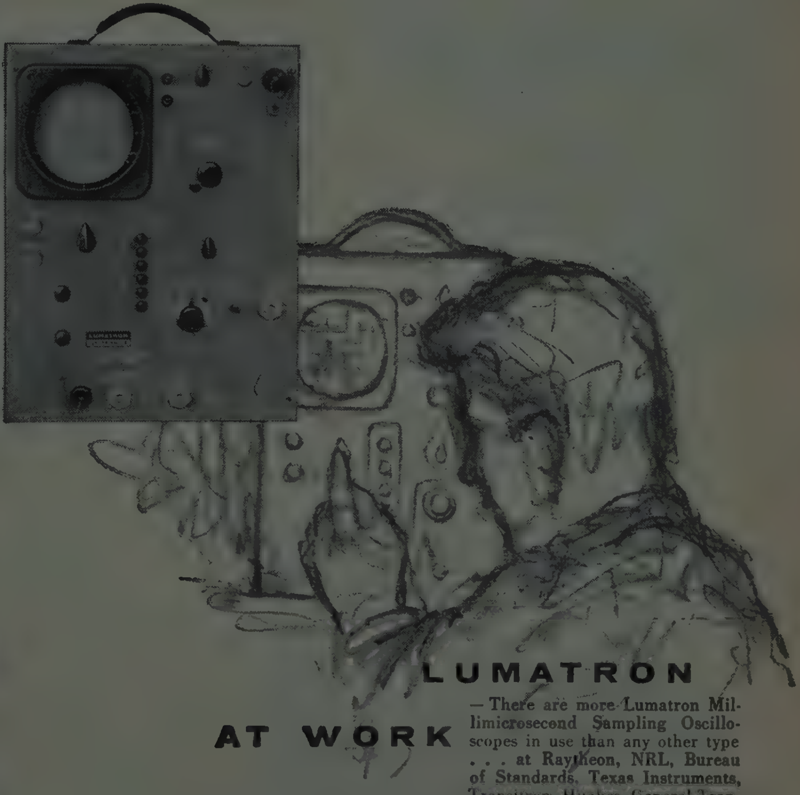

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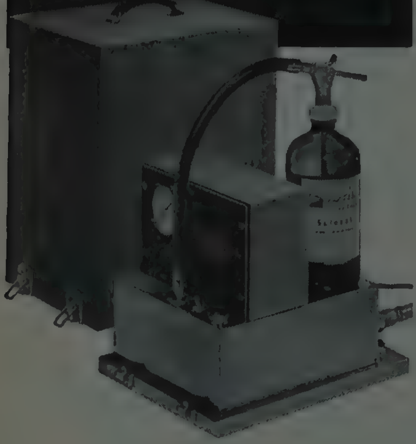

APPLICATIONS

Electronic Components & Assemblies: Diodes, Transistors, Slip-Ring Commutators, Crystals, Vacuum Tube Components, Sub-Miniature Assemblies.

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Whom and What to See at the Radio Engineering Show

(Continued from page 323A)

Mincom Division
Minnesota Mining & Mfg. Co.
2049 South Barrington Ave.
Los Angeles 25, Calif.
Booth 3923

▲R. J. Brown, J. E. DeLand, C. S. Tobias

New Instrumentation Magnetic Tape Recording/Reproducing Equipment.

Minneapolis-Honeywell, Boston Division, Booth 2208
40 Life Street
Boston, Mass.

George Bailey, Richard S. Burwen, Leonard P. Entin, Donald G. Lynam, Frank Melanson, John W. Rhinesmith

Gyros; M-100, Golden Gnat (cutaway), JRT, "Star of Gyros" panel (Gnat three axis package for F-106), Accelerometers; LA-500, LA-600 and LA-700, AccuData series d-c amplifiers, T6GA Galvanometer amplifier, 2HLA-9 Differential Input Indicating Amplifier, 2HCT Precision Temperature Controller.

Minneapolis-Honeywell, Davies Division, Booth 2214
10721 Hanna St.
Beltsville, Maryland

J. D. Mitchell, G. A. Lacas, J. G. Booth, N. S. Bassett, H. H. Barnes, R. M. Hadley, R. O. Hutchinson, C. J. Clarke

Analog Direct and FM Record and Playback System, Loop Transport, Wave Analyzer, Record and Playback single and multi-channel Head Display.

Minneapolis-Honeywell
Marion Electrical Instrument Division
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E. S. Maury, H. A. Donahue, Jr., E. E. Doherty, Gordon Steady, Richard Rattigan, Herbert Lawrence, Jr.

AC Iron Van Panel Meters, Medalist Meters, Ruggedized Meters, Aircraft Instruments, Miniature Indicators and Mechanisms.

Minneapolis-Honeywell, Micro Switch Division, Booths 2204-2206
Freeport, Illinois

John Tropsa, Gerald Boyle, William Betz, Robert Remley, Sidney Doctor, Robert Schrader, Jack Ellis, Arnold Bahnsen, Alfred Bahnsen, Sylvan Markosian, Walter Landers, Robert Eadie, Eugene Moran, Donald Guide

Bifurcated-contact subminiature switch, "One-Shot" pushbutton assemblies, Snap-acting pushbutton switches, Alternate-action pushbutton switch, Rapid-repeat, light-touch pushbutton, Decimal-to-binary rotary input switch, Subminiature door inter-lock switch, Minature toggle switch and Environment-free sub-miniature switch.

First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Minneapolis-Honeywell
Rubicon Division
Ridge Avenue at 35th St.
Philadelphia, Pennsylvania
Booth 2210

Alex Schoemann, Lou Gill, Earl Benson

Wheatstone Bridge, Kelvin Bridge, Potentiometers, Galvanometer, Resistors (NBS and Reichsanstalt).

Minneapolis-Honeywell, Semiconductor Division, Booth 2212
1015 S. 6th St.
Minneapolis, Minnesota

R. O. Anderson, S. L. Furber, R. L. Larsen, L. T. Macgill, R. E. Mock, W. R. Rittman, M. C. Walker

Germanium power transistors; triodes and tetrodes.

Minneapolis-Moline Company, Booth 3952

See: Molectronics Corp.

Minnesota Mining & Mfg. Co., Magnetic Products Div., Booth 1913
900 Bush Ave.
St. Paul 6, Minn.

Dan Denham, Wm. F. Enright, James L. Kamiske, Charles A. Alden, J. Bimrose, J. Rogers, P. Van Deventer, John Watson, Robert Patterson, P. J. Cafferty, J. F. Maye, J. G. Bondus

"Scotch" Brand Instrumentation Tape (Magnetic) and Accessories.

Minnesota Mining & Mfg. Co., American Lava Corp. & Mincom Div., Booths 4502 & 3923

See: American Lava Corp. & Mincom Division.

Mitchell-Rand Mfg. Corp., Insulation Div., Booth 4123
51 Murray St.
New York 7, N.Y.

John R. Mitchell, Jr., William A. Ingraham, John J. Finn, Joseph Konkolosky, Harry Bych, Don Pennett, William Lange, Frank Whelan

Epoxy Resins, Impregnating Waxes, Potting Compounds, General Line of Electrical Insulating Materials.

Mitronics Inc.
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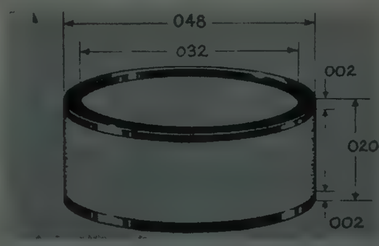
Booth 1815

Harvey Pensack Smith, Bob Eaves, Tony Monari, Allan Davis, Lloyd Lamb, Jerry Lynch, George Resetter, Billy Schulz, Ed Domber, Jerry Mullen, Norman Mullen, Herb Thode, Carl Engle, Paul Hollenbeck, Hart Vancroft, Lloyd Moore



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(Continued on page 326A)

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Measure transistor characteristics—

Alpha (h_{fb})
Beta (h_{fe})
Input Resistance (h_{ib})

—with the new BRC Type 275-A Transistor Test Set

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BOOTHS 3101-3102

The BRC Type 275-A is an exceedingly flexible and efficient instrument for the precise measurement of basic transistor parameters over an extended range of operating conditions. It can also be used to measure the characteristics of diodes and other semi-conductor devices. Direct readout of the following parameters—

• Alpha (h_{fb}) • Beta (h_{fe})
• Input Resistance (h_{ib})

is presented on a large, easy-to-read dial without correction or interpolation. Two built-in, fully regulated, low ripple power supplies furnish completely variable emitter current and collector voltage.

SPECIFICATIONS

Alpha Measurement (h_{fb}):
RANGE: (a) 0 to 0.99
(b) 0.9 to 0.999
ACCURACY: (a) ± 1%*
(b) ± 0.5%*
*when f ≧ 500 Kc.

Beta Measurement (h_{fe}):
RANGE: 0 to 200

Input Resistance Measurement (h_{ib}):
RANGE: (a) 0.3 to 30 ohms
(b) 3 to 300 ohms
(c) 30 to 3000 ohms
ACCURACY: (a) ± 3%*
(b) ± 3% above 30 ohms*
* for linear impedances

Internal Test Oscillator:
FREQUENCY: 1000 cps
ACCURACY: ± 5%

Collector Voltage Supply:
RANGES:
Internal: 0 to 100 V.D.C.
External: 0 to 100 V.D.C.
METERING:
Range: 0 to 2, 5, 10, 50, 100 volts
Accuracy: ± 1.5% full scale

Emitter Current Supply:
RANGE:
Internal: 0 to 100 ma D.C.
External: 0 to 5 amp. D.C.
METERING:
Ranges: 0 to 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 ma.
Accuracy: ± 1.5% full scale

Exclusive BRC features—

- Unique null-type measuring circuit completely unaffected by signal level fluctuations
- Reads Alpha to three significant figures
- Accurately measures at extremely low emitter currents

—plus

- Permanent Calibration
- Direct Readout of Alpha, Beta, and Input Resistance on large easy-to-read dial
- Built-in adjustable, metered collector and emitter power supplies
- Handles up to 5 amperes emitter current
- Measures both NPN and PNP transistors
- Special test circuit guards against transistor burnout

Precision Electronic Instruments since 1934

BOONTON RADIO CORPORATION
BOONTON • NEW JERSEY • U.S.A.

Whom and What to See at the Radio Engineering Show

(Continued from page 324A)

Model Engineering & Mfg., Inc., Booth 2305
See: Tru-Ohm Products Div.

Moeller Instrument Company, Inc., Electronics Division, Booths 2005
132nd St. & 89th Ave.
Richmond Hill 18, N.Y.

▲ Charles Beck, Jr., ▲ John B. Chatterton, ▲ David G. Hollister, Joseph A. Reale

Isolated dc Power Supplies, Power Isolators, Isolated Line Voltage Sources for instrumentation and testing. Engineering, research and manufacturing facilities for any instrumentation isolation problems.

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Josh Gershuny, Harry Robertson, ▲ Joseph Steinfeld, Charles Stewart

Electronic test equipment and instrumentation; digital voltohmmeters, digital ratiometers, digital counter units, vacuum tube voltmeters, oscilloscopes, relay testers, and custom instruments; portable and rack mounting units.

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10 a.m. to 9 p.m. daily

Monday through Thursday

March 21-24, 1960

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Booth 4242

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Fine and superfine resistance wire .0004″ to .010″ diameter. Bare, enamelled, oxidized and fabric covered finishes. Also precision grade Grid Lateral wires.

Monroe Calculating Machine Co., Booths 1610-1618, 1709-1717
See: Litton Industries, Inc.

Monsanto Chemical Co., Booths 4026-4027
800 N. Lindbergh Blvd.
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Monsanto Organic Chemicals Div.: F. H. Langenfeld, R. A. Steenrod, A. G. Eades, Denis Perry, R. Draper, P. G. Benignus, M. McEwen

Coolanol 45 coolant-dielectric for electronic equipment. Aroclor series of dielectrics for capacitors, transformers. Radiation-resistant, other synthetic fluids.

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ELEVATOR

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Your name gives you identity. A tool has a "name" A part has a "name" A switch has a "name" Everything in your plant has a name, from who works for you to the Engrave all these "names" permanently with unskilled labor by

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X-Y Recorders, Strip Chart Recorders, Logarithmic Converters, AC to DC Converters, Continuous Line Followers, Magnetic Curve Followers, Punched Tape and Card Converters, Servo Voltmeters, Magnetic Tape Converters.

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Brewster, N.Y.

Donald P. Mossman, Jr., Ben Rist, Ed Brunner, Alan MacLachlan, Robert Maher, Wm. Brabant, Herb Kahn

Lever Switches, multiple contact, 3 to 20 Ampere. Push Button Switches, Interlocking, momentary, *Alternate action, Illuminated. *Series 5900 and 7700 now available with detachable contact assemblies to facilitate changes in contacts, simplify stocking. Dust covers to enclose pileups also available.

Motorola Inc.
Semiconductor Products Division
5005 East McDowell Road
Phoenix, Ariz.
Booths 1114-1115

▲ Richard H. Rudolph, ▲ F. Joseph Van Poppelen, ▲ James LaRue, ▲ A. B. Dall, ▲ H. I. Ackerman, ▲ Charles F. Scott, William A. Kraus, David P. Hall, Robert R. Thomas, Raymond G. Kimbell, Edward J. Loyd, Arthur Powell, ▲ Glen Madland, G. E. McGonagle, ▲ Larry Kelly, James Lucy, John L. Gray, Jerry Sanders

New ¼ Watt glass silicon Zener Diodes

Motorola presents important design information, reliability data and working applications on UHF Mesa Transistors; Industrial Alloy and Power Transistors; Silicon Rectifiers (including automotive); and the industry's most complete line of Silicon Zener Diodes, reference elements and glass diodes.

Mucon Corp.
9 St. Francis St.
Newark 5, N.J.
Booth 2807

M. A. Prince

NARROW-CAPS
fit
1/10
MODULAR SPACING
.10″

Subminiature ceramic capacitors tailored to your space requirements. Various ceramics for choice of properties. Ribbon, wire and tab lead arrangements. Low-voltage, high-capacitance units for transistor circuitry. NARROW-CAPS for 1/10 inch mounting.

(Continued on page 328A)

▲ Indicates IRE member.
* Indicates new product.

INTRODUCING

ANTENNA SYSTEMS INC.

A new corporation devoted exclusively to the design, fabrication and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy and special antenna products.

A word from the new president, Charles Creaser . . . "Ours is primarily an engineering organization which is employee-owned and employee-run. Our objective can be stated simply: it is to lead in the development and introduction of new and improved techniques and processes. We are equipped to handle the entire antenna system — reflectors, mounts, feeds, pedestals, waveguide, rotary joints — everything from transmitter and receiver on."

. . . and from the vice-president, Bill VanderWolk "We're off to an exciting start. We've taken a new approach to antenna marketing by building a new, 30-foot parabolic dish for space tracking and communications, which promises to be more accurate than anything yet built. Very soon, we'll have the finished product, built and operating, to show to industry and government. Instead of offering a design and a promise of performance, we'll prove ours first.

For more information, please send for our folder

ANTENNA SYSTEMS INC.

Hingham Industrial Center, Hingham, Mass.

now available in a wide range of

STANDARD SIZES

BTI

precision tooled beryllium copper

CLIPS

for: **Transistor, Capacitor, Diode, Fuse and Component applications.**

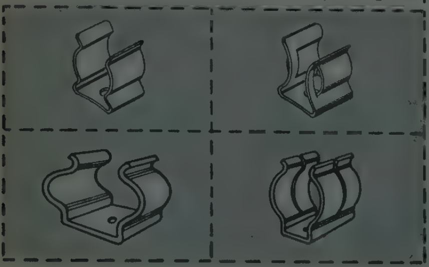
B T I electronic clips are now stocked for prompt shipment in a complete range of standard sizes and designs. The use of beryllium copper and associated alloys insures positive spring contact pressure with exceedingly high electrical and thermal conductivity.

Write today for the new series of B T I bulletins showing standard sizes with specifications.

BTI *B T I also offers standard grounding strips and ring contacts for all electronic requirements.*

Write for Bulletin #E-106.

BRAUN TOOL & INSTRUMENT
COMPANY, INC.
143 Fifth Ave., Hawthorne, N. J.



Whom and What to See at the Radio Engineering Show

(Continued from page 326A)

Muirhead & Co., Ltd., Booth 3230
Beckenham, Kent, England

See: Muirhead Instruments, Inc.

Muirhead Instruments Inc.
441 Lexington Ave.
New York 17, N.Y.
Booth 3230

▲ J. V. Foll, J. A. Muirhead, ▲ P. L. Irvine, A. E. W. Hibbitt, A. Cooper, L. W. Fenn, ▲ A. Roy Smith, ▲ F. A. Miles, E. A. Conte, L. F. Purcer

Automatic Analyser Equipment

*Automatic Wave Analyser, 10 c/s to 19k c/s for automatic analysis of complex noise and vibration waveforms. Wide range Decade Oscillator 1 c/s to 100k c/s. *High Frequency Analyser-Oscillator 200 c/s to 650k c/s. *Special type Synchros and Motor Generators. Weston Standard and Reference Cells.

Murata Manufacturing Co., Ltd., International Division, Booth 2006
Kaiden, Nagaoka-Cho
Otokuni-Gum, Kyoto, Japan

Tatsuya Akebi, ▲ Osamu Saburi

Ceramic Capacitors, high temperature and close tolerance. Subminiature type Tuners for applications in radio, T.V., and Computers. Latest developments in Mechanical Filters and Tuning Forks.

Mycalex Corp. of America
125 Clifton Boulevard
Clifton, N.J.
Booths 2729-2731

Edward de Villeroy, George Lynch, Winfield Darrow, William Ormston, Thomas Weber, John Froemel, Francis Barr, Henry Richardson, A. Monack, Richard Young

MYCALEX® glass-bonded mica precision-molded tube sockets, arc shutes and high temperature electrical components and parts. SUPRAMICA® ceramoplastics—telemetry switches, commutator plates, RF coil supports and high temperature electrical components and parts. SYNTHAMICA® synthetic mica—powders, paper, crystals in various forms.

▲ Indicates IRE member.
* Indicates new product.

A complete listing of all registrants at the IRE National Convention and Radio Engineering Show, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

NRC Equipment Corp.
160 Charlemont St.
Newton Highlands 61, Mass.
Booth 4427

J. H. Moore, R. H. Binkerd, S. G. Burnett, H. M. Farrow, G. King, Jr., D. D. Preis, J. J. Flood, B. Thorley

*Multiple-source Laboratory Vacuum Coater. *High Speed (1550 1/s) 6″ Fractionating Diffusion Pump. *High Performance Mercury Diffusion Pump for lamp exhaust. *Nottingham UHV (to 10^{-10}mm. Hg.) Ionization Gauge Control. *Redhead UHV (to 10^{-14}mm. Hg.) Gauge and Control. *Battery-Operated Thermocouple Gauge. *Extreme Altitude Radio-Sonde.

Narda Microwave Corp.
118 Herricks Road
Mineola, L.I., N.Y.
Booths 3815-3817

▲ J. C. McGregor, ▲ W. A. Bourke, ▲ S. D. Casper, ▲ J. E. McFarland, ▲ L. I. Kent, ▲ A. Brenner, ▲ R. Othmer, ▲ D. R. Robertson, ▲ H. S. Bertan, ▲ Philip Levine, ▲ P. Lubell, ▲ B. Maher, ▲ A. Coronis, ▲ L. Lipset

Microwave UHF Test Equipment & Components including Waveguide & Coaxial Direct Reading Frequency Meters, Attenuators, Directional Couplers, Bolometer and Thermistor Mounts and Impedance Meters. Klystron Power Supplies, VSWR Amplifiers, Power Meters, Frequencies cover 200 to 90,000 mc.

Narda Microwave Corp.
HPED Division
118-60 Herricks Road
Mineola, L.I., N.Y.
Booth 3813

▲ Howard Bertan, ▲ Leonard Kent, ▲ William Bourke, ▲ Stuart Casper, ▲ James McFarland, Karl Reuchlein

High Power Pulse Modulators and High Voltage Power Supplies. Catalog Item Versatile Modulators for Magnetron and Klystron Pulse Operation. Test Modulators and Power Supplies for Laboratory and Production Testing.

Narda Ultrasonics Corp., Booth 4532
625 Main St.
Westbury, L.I., N.Y.

▲ Dr. John C. McGregor, Walter H. Venghaus, Paul W. Steen, Strain Sutton, Norman Padden, Richard Fallon, ▲ Robert Markel, ▲ Martin A. Damast, ▲ Morris Kenny, ▲ Eugene Black

Showing a complete line of ultrasonic cleaning equipment from 35 watts to 3 kw, including transducerized tanks as well as immersible transducers. Inquiries on custom installations are invited. Showing for the first time a completely transistorized unitized ultrasonic cleaner.

National Carbon Co., Booths 2401-2403

See: Union Carbide Consumer Products Co.

National Cash Register Co.
Electronics Div.
1401 E. El Segundo Blvd.
Hawthorne, Calif.
Booth 1912

L. J. Hines, W. Irwin, E. J. Haley

A line of computer memory components. Cylindrical thin film electro-deposited magnetic rod; magnetic rod array, High speed magnetic rod memory; Ferrite core array for memory applications meeting extreme environmental conditions; micro-encapsulation and photochromism.

National Co., Inc., Booths 1401-1407
61 Sherman St.
Malden 48, Mass.

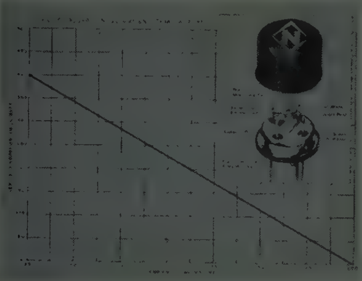
S. L. Rudnick, E. R. MacDonald, R. H. Rogers, ▲ F. Roberts, S. W. Natkin, J. H. Quick, H. C. Guterman, ▲ E. Grant, ▲ S. Fast, ▲ P. Smith, ▲ J. Hannigan, ▲ Hal Moyer, ▲ Earl Sloane, ▲ Stan Turner

Radio Receiver equipment, Electronic components, Elasticable, Servo Motors, Generators and Systems, ATOMICHRONS, and Military Ionospheric and Tropospheric Scatter Communications Equipments and Components.

National Research Corp., Booth 4427
See: NRC Equipment Corp.

National Semiconductor Corp.
Sugar Hollow Road
Danbury, Conn.
Booth 2007

▲ Dr. B. Rothlein, Dr. E. Clarke, J. Gruber, Dr. R. Rau, R. Hopkins, G. Schneider, J. Hegarty, B. Wonnacott, Dr. M. Schneider, D. Harris, R. Hunchak



Silicon Transistors: PNP Alloy—2N1440 series & 2N327A series, highest device dissipation (400 mw at 25°C, 170 mw at 125°C), surpassing all industry specifications, for small signal and medium power applications; NPN Mesa—2N702 series & 2N560 for switching and computer applications.

National Union Electric Corporation, Electronics Division, Booth 1328
Bloomington, Ill.

▲ E. R. Ewald, B. J. Hart, H. B. Graham, D. E. Bartmess, ▲ W. R. Schweikert

Special purpose vacuum tubes, high voltage regulator, miniature cathode ray tube, wide band secondary emission amplifiers and numeral glow readout tubes.

Navigation Computer Corp., Booth 3223
1621 Snyder Ave.
Philadelphia 45, Pa.

J. Paul Jones, Jr., David M. Biberman, ▲ Henry Longley, Jr., Henry Apfelbaum

Transistorized digital systems modules, including Shift Registers, Binary Counters, Reversible Counters, Decade Counters, Digital Delays, Switches, Gates, Digital to Analog Converters, NOR Logic, etc. Featured will be a new Numerical Read-Out Device.

Nems-Clarke Co., Div.
Vitro Corp. of America
919 Jesup-Blair Drive
Silver Spring, Md.
Booths 3826-3828

▲ A. S. Clarke, ▲ R. E. Grimm, J. F. Whitehead, K. B. Redding, R. P. May, R. C. Curry, P. Dudney, M. L. Bandler, T. W. Maskell, D. H. Steinweg, C. Hall, W. H. Kimbell

Complete Line of RF Telemetry Equipments, Receivers, Preamplifiers, Multicouplers, Spectrum Display Units, Range Extension Units, Jacks, Jack Strips and Broadcast Items.

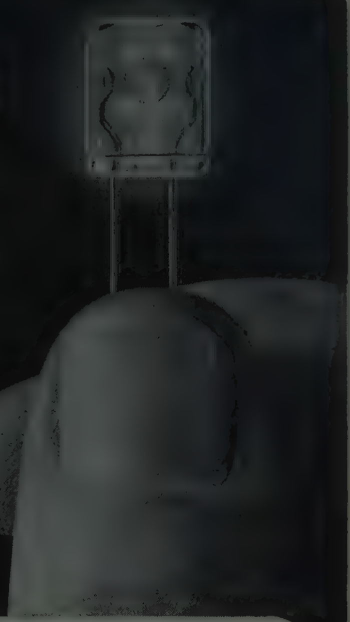
New Haven Clock & Watch Co., Booth 2140
See: Condenser Products Div.

(Continued on page 332A)

McCoy

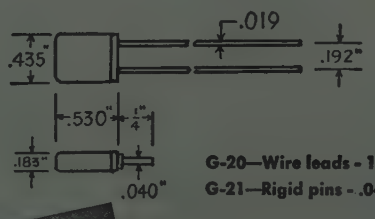
G-20 & G-21 MINIATURE
ALL-GLASS
HC-18/U TYPE
CRYSTAL
UNITS

Possess all of the quality and dependability for which the McCoy line of metal-encased crystal units is famous.



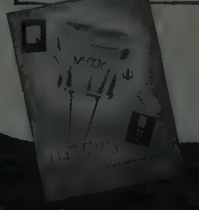
Check these advantages:

- ✓ Excellent Long-Term Stability
- ✓ Minimum Aging
- ✓ Choice of Leads — Pins or Flexible Wire
- ✓ Maximum Resistance to Shock and Vibration 30 vector G's from 20 to 2000 cps — vibration 100 G's — shock
- ✓ True Hermetic Seal Altitude is no problem
- ✓ Meets new CR-73/U and CR-74/U Specs
- ✓ Wide Range of Frequencies Available 5000 KC to 200,000 KC
- ✓ Extremely Small Size



Shown actual size.

G-20—Wire leads - 1½" or specify.
G-21—Rigid pins - .040 dia. ¼" long.



Write today for our free illustrated catalog which includes complete listing of military specifications. For specific needs, write, wire or phone us. Our research section is anxious to assist you.

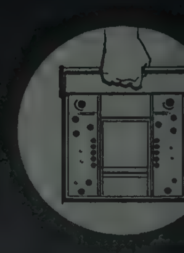
McCoy ELECTRONICS CO.
Dept. P-3
MT. HOLLY SPRINGS, PA.
Phone HUnter 6-3411
BE SURE TO SEE US AT THE I. R. E. SHOW - BOOTH 2311

NEW

MODEL 320

PORTABLE 2-CHANNEL

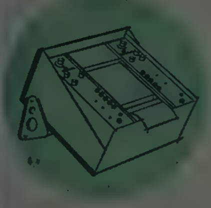
DAMPING
COMPENSATION
MONITOR OUTPUT
INPUT



The new Sanborn Model 320 system — for general purpose DC recording in any part of the plant or on field assignments — combines rugged current-feedback amplifiers, 2-channel recorder assembly and dependable all-transistor circuitry in less than a cubic foot of space. And the many advantages of Sanborn multi-channel systems are incorporated in the new portable 320 — low impedance, enclosed galvanometers; clear, permanent traces made by heated styli; rectangular coordinate charts. Most components for each channel are mounted on one easily serviced card; others are readily accessible. The control panel permits easy access to the controls for each channel . . . provides for observation of 6 inches of the chart . . . and it can be set up for use vertically, horizontally or at a 20° angle using the adjustable stand/carrying handle.

Your nearest Sanborn Sales-Engineering Representative can provide you with complete data or write the main office in Waltham. Sales-Engineering Representatives are located in principal cities throughout the U. S., Canada and foreign countries.

DIRECT WRITING SYSTEM



- **up to 0.5 millivolt/mm sensitivity**
- **inputs floating and guarded for each channel**
- **rectangular coordinate charts full 50 mm wide**
- **only 12¾″ square, 8¾″ deep**
- **4 pushbutton chart speeds**
- **completely transistorized**

SPECIFICATIONS

electrical

Sensitivity Ranges	0.5, 1, 2, 5, 10, 20 mv/mm and v/cm
Input Impedance	½ megohm on mv/mm ranges and 1 megohm on v/cm ranges
Frequency Response	3 db down at 125 cps, 10 div peak-to-peak
Common Mode Voltage	± 500 volts maximum
Common Mode Rejection	140 db minimum DC
Linearity	maximum non-linearity — 0.2 mm with respect to chart center
Calibration	10 mv internal signal ± 1%
Limiting	approx. ± 115% of full scale
Rise Time	4 milliseconds with less than 4% overshoot

physical

Input Connectors	separate for each channel
Output Connectors	40 mv/mm sensitivity for connection of external monitoring scope to each channel
Dimensions	approx. 12¾″ by 12¾″ by 8¾″
Weight	approx. 55 lbs.

Controls

(for each recording channel)

Range Switch	6 positions and off
Smooth Gain Control	
Function Switch	4 positions — Zero, Cal, Use mv/mm Use v/cm
Position Control	
Stylus Heat Control	
Galvanometer Damping	(screwdriver adjusts.)
Galvanometer Compensation	

(for the entire system)

Power ON-OFF	
Speed Control	1, 5, 20, and 100 mm/sec
Marker-Off-Timer	

Data subject to change without notice.

See this new System at the I.R.E. Show—Booths 3601—03—05

SANBORN COMPANY

INDUSTRIAL DIVISION 175 Wyman Street, Waltham, Massachusetts

Ultra-Reliability
is our watch word at
GUIDANCE CONTROLS CORP.

SIZE 9
POT.-CLUTCH
MODULE

Pancake style, 2.5 watt clutch coil.
Rated Torque: Mag. energized . . . 16 oz. in. Mech. energized . . . 8 oz. in. Pot. wiper integral with clutch shaft, zero backlash, zero axial play. Specs. for GCP-9 same as listed below for Precision Pots. & Magnetic Clutches.

MINIATURE GEARHEAD
MOTOR, SIZE 11

Ratios from 5:1 to better than 78,000:1 as required.
Operating Load Torque . up to 100 oz. in. max.
Backlash: 30 minutes max. for any ratio.
Gearing: Precision Class II
Bearings: ABEC Class 5
Shaft End Play: .002" max. measured with 1 lb load.
Shaft Radial Play: .0005" max. measured with 4 oz. load.

PRECISION
POTENTIOMETERS
A complete line of linear and non-linear potentiometers.
LINEARITY . . .
Standard .08%
Best .03%
MAXIMUM
RESOLUTION .015%
Low torque, low noise, excellent stability.
Exceeds MIL 5272 and NAS 710.

MAGNETIC
CLUTCHES
Unique electro-magnetic design provides for extreme torque to inertia ratio . . . over 1,000,000 rad./sec².
SPECIFICATIONS
- Zero backlash and .0005" max. end play
- Friction face
- ABEC-5 ball bearings
- .0015" TIR input/output shaft concentricity with servo mount pilot
- Exceeds MIL-5272, 4158, and 8189 specs.

See us at the
I.R.E. SHOW . . . . BOOTH M-2

SUB & MICRO MINIATURE
MAG. CLUTCH BRAKES

- Most advantageous for critical size/critical weight applications
- 14 models available in sizes 6 and 8
- High torque to inertia ratio. Zero backlash and end play.
- Exceeds MIL-E-5272, 4158, and 8189 specs.

SEND FOR FREE
DATA SHEETS

GUIDANCE
CONTROLS CORP.
110 Duffy Ave.
Hicksville, N. Y.
a subsidiary of Dyna-Magnetic Devices Inc.

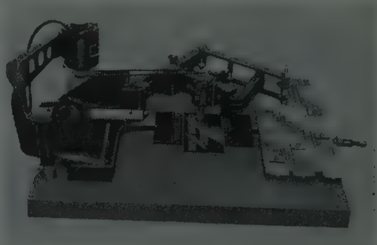
Whom and What to See at the Radio Engineering Show

(Continued from page 329A)

New Hermes Engraving Machine Corp.

154 West 14th St.
New York 11, N.Y.
Booth 4035

N. Schimmel, H. Susskind, W. Dannheisser, G. Berlant, M. Kaufman, R. H. Laird



Engravograph

Portable and bench type engraving machines, tracer-guide for unskilled labor. Special equipment for drilling printed circuits. Ultrasonic industrial cleaning machines. Nameplate beveller, Cutter grinder. Laminated engraving stocks. ENGRAVOGRAPH, the pantograph engraving machine for nameplates, dials, panels, routing & milling on all plastics & metals—unlimited dimensions.

New York Air Brake Co., Kinney Vacuum Division, Booths 4309-4311

See: Kinney Vacuum Division

Nicad Division, Gould-National Batteries, Inc., Booth 1116

172 Pleasant St.
Easthampton, Mass.

W. R. Albrecht, F. C. Anderson, A. H. Lindsay, L. R. Mannheim, R. T. Perron, R. L. Ringer, T. Ulrich, J. D. Whittemore, Jr., R. L. Wilkinson

NICAD nickel cadmium batteries are reliable, compact, light in weight, have low resistance and provide sustained voltages at high discharge rates over a wide temperature range. They recharge rapidly, withstand shock, vibration and indefinite storage. No corrosive fumes—low maintenance.

Non-Linear Systems, Inc.

Del Mar Airport, Box 728
Del Mar, Calif.
Booths 3041-3042

Andrew F. Kay, Richard C. Wynne, Peter Van Benschoten, Ben Fisher, Robert Landay, Thomas E. Nawalinski

Operate-it-yourself display of digital voltmeters and voltage comparators for research, inspection, standards labs, auto control, data loggers. Modern packaging permits changing instruments parts in 10 minutes. Introducing new digital at price of laboratory type pointer meters. Precision resistors.

Norbute Corp., Booth 2134

See: Kurman Electric Co.

Norrich Plastics Corp., Booth 4046

206 Babylon Turnpike
Roosevelt, L.I., N.Y.,

Richard E. Thaw, Philip Brody

Epoxy Bobbins, Epoxy Coils, Epoxy Potting Capsules, Plastic Screw Machine Products, Precision Metal Servo Machine Products, Molded Plastic (Epoxy) Parts, Precision Metal Screw Machine Products.

North American Electronics, Inc.

71 Linden St.
West Lynn, Mass.
Booth 2009

Raymond W. Smith, Charles H. Trout, William C. Cacciatore, Paul Norton, Dick Henry, James Wall, Arthur H. Bruno, Avio DiFelice, Paul Flaherty, Peter Whoriskey, Joseph C. Miller

Development and production of semiconductors to standard and special specifications to meet customer requirements. Standard product lines include miniature diodes, low and medium power rectifiers. 150 MW to 50 watt avalanche diodes. 50 mA to 20 amp. silicon controlled rectifiers.

North Atlantic Industries, Inc.

603 Main Street
Westbury, L.I., N.Y.,
Booth 3833

▲ Malcolm D. Widenor, ▲ Walter Lipkin, Sidney Herman, John A. Gregorio, ▲ Herbert W. Bass, ▲ J. P. Brogan, ▲ E. V. Donegan, ▲ E. Brown

*New Model RB-504 Ratio Box

Single, Multiple & Broadband Frequency Phase Angle Voltmeters, Portable & Militarized. Precision AC Inductive Voltage Dividers & Standards, Complex Voltage Ratiometers. Modular AC-DC Phase Sensitive Converters. Oscilloscope. Ratio Test Sets. Servo Driven Self Balancing Indicators (Military & Commercial Applications) with Repeating Indication of Temperature, Millivolts, Ratio, Synchro, etc.

North Electric Co., Booth 2125

553 South Market St.
Galion, Ohio

H. H. Brewer, W. F. Keally, J. V. Guercio, P. Van Valkenburgh, W. F. Tidd, H. R. Rivitz, ▲ W. W. Crissinger, C. V. Schuster, T. W. Parsons, R. E. Pickett, G. Hinkle, R. Rosenkoetter

System Techniques utilizing North products such as Supervisory Control, Electronic Switching, Automatic Controls, Transistorized Tone and Voice Communications Equipment, Amplifiers, Relays, Crossbar, Rotary Stepping Switches, Connectors, Transistorized Power Supplies, Electric Counters.

North Hills Electric Co., Inc.

402 Sagamore Ave.
Mineola, L.I., N.Y.
Booth 3023

Sydney Cramer, Leo Staschover

CS-117 Gyro Torquer Supply

Equipment Department: Constant Current Supplies for testing gyros, diodes, transistors, relays, magnetic cores, batteries, fuses, bolometers, accelerometers. Components Department: Coils, toroids, filters, wide band transformers.

Northeast Scientific Corp., Booth 2844
30 Wetherbee St., RFD 1
South Acton, Mass

▲ Clement Moritz, John J. Hogan, John T. Parkhill

Regulated High Voltage Supplies with maximum voltages to 10 kv and output currents to 1 ampere, Constant Current Supplies, and Millimeter Wave Generators.

Northeastern Engineering, Inc., Booth 3108
25 S. Bedford St.
Manchester, N.H.

▲ C. N. Chagaris, ▲ C. J. Kannair, Jr., ▲ B. E. Lamere, ▲ J. L. McCluskey, ▲ N. L. Westlake

Development and manufacture of Frequency, Period, and Time Interval Measurement Instruments and Systems. Frequency Counters and Converters, *Frequency Standards, *Digital Printers, *Code Converters, *Preset Decades and Decade Scalers. Inertial Gyro Test Equipment.

Northern Radio Co., Inc.
143-7 West 22nd St.
New York 11, N.Y.
Booth 3510

▲ S. A. Barone, ▲ A. J. Odgers, ▲ F. C. Lambert, ▲ J. S. Harris, ▲ P. Flamholtz

Transistorized Voice Frequency Telegraph Carrier Equipment AN/FGC-61

Northrop Corp., Booth 3932
See: Page Communications Engineers, Inc.

Nothelfer Winding Laboratories, Inc.
220 Ewingville Road
(P.O. Box 455)
Trenton 3, N.J.
Booth M-13

John J. Nothelfer, Joan Suleskey, Paul Walshin

Gapless core transformers, control reactors—maximum KVA, minimum losses and magnetizing currents. Highest efficiency in power and instrument transformers. Toroidal magnetic circuits at cost of production transformers. VARI-HENRY adjustable inductance—TAK-A-PART transformer, reactor, saturable reactor—Current transformer through type single and multi-ratio—Toroidal Cores, grain oriented, silicon-steel—Frequency-doubling transformer.

Oak Manufacturing Co., Booth 2921
1260 North Clybourn Ave.
Chicago 10, Ill.

▲ L. H. Flocken, H. Howell, P. Parasoe, R. McTigue, W. Cochrane, P. Wheaton, H. Olson, E. Olenick

Low Power Rotary, Slider, Lever and Push-button Actuated Switches, Including New Line of "Stock" Switches. AC/DC Choppers, TV Tuners. Variable Capacitors, Rotary Solenoids, Vibrators, Appliance Timers.

Offner Electronics Inc.
3900 N. River Road
Schiller Park, Ill.
Booth 3051

George W. Little, ▲ Dr. Franklin F. Offner, James Janisch, Richard Cozak

Type R Dynograph multichannel direct-writing oscillograph, all transistor, one microvolt dc sensitivity and convertible recorder. Also 12 to 19 channel writer console, dc differential data amplifiers and other recorders.

(Continued on page 334A)

▲ Indicates IRE member.
* Indicates new product.

THE LEADER
in R.F. Voltage Measurements
at Low Level

from 10 KC to 600 MC

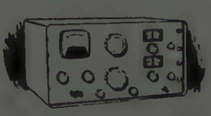
MODEL 91-CA
300 microvolts to 3 volts
Price: $495

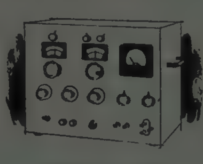
MODEL 91-C
1000 microvolts to 3 volts
Price: $395

VOLTS
BEC
DB
RANGE-FULL SCALE
BALANCE
PROBE
ON
RF VOLTMETER
MODEL 91-CA
Boonton ELECTRONICS Corp.
MORRIS PLAINS, N.J.

ALSO MANUFACTURERS OF THE FOLLOWING INSTRUMENTS:

DC Millivoltmeter


Inductance Bridge


Capacitance Bridge

UHF Grid Dip Meter

Boonton ELECTRONICS Corp.
Morris Plains, N. J. • JEfferson 9-4210
SEE US AT THE SHOW, BOOTH #3114

Whom and What to See at the Radio Engineering Show

(Continued from page 333A)

Ohmite Manufacturing Co.
3601 Howard St.
Skokie, Ill.
Booths 2333-2335

Roy S. Laird, Kenneth M. Arenberg, Edward A. Rehe, Manny Forester

Model "E" 12½ Watt Miniature Rheostat

*Etched foil tantalum capacitors; *two new larger sizes plain foil tantalum capacitors; *ceramic wafer metal film, micromodule resistor; *tiny 1 watt wirewound resistor; *7 watt molded power precision resistor; *20 ampere variable transformer; *new line 30 volt high amperage variable transformers. Rheostats, Switches, Chokes, Diodes.

Oliver-Shepherd Industries, Inc., Booth 2937

See: Shepherd Industries, Inc.

Optical Coating Laboratory, Inc., Booth 4049
977 Sebastopol Rd.
Santa Rosa, Calif.

▲ Rolf Illsley, Danforth Joslyn

Development and manufacture of vacuum deposited thin film coatings. Infrared Spectrum: Wide Band Pass, Long Wavelength Pass, Narrow Band Pass Filters, 2-color filters. Visible Spectrum: Gunsight Reflectors, "Hot" Mirrors, "Cold" Mirrors, High Reflecting Mirrors, Multilayer Antireflection coatings. Infrared Heat Shielding on Fiberglas.

Optimized Devices, Inc.
864 Franklin Ave.
Thornwood, N.Y.
Booth 3016

Arthur Zuch, James Murtha, Sergio Bernstein

Caftron

Caftron—*New Automatic Semiconductor Test Equipment. (In use at C.P. Clare booths 2218-20 as well) *New precision AC-DC Voltage Comparators. Multiconductor Cable Test Sets. Automatic Test System Modules for Ground Support, Production Testing, Incoming Inspection, and Quality Control.

Be sure to see all four floors!

Ortho Filter Corp., Booth 1626
7-11 Paterson St.
Paterson 1, New Jersey

George G. Pagonis, ▲ Jerome Potash, Wm. McGravey, Tom Fogg

Complete line of filters—low, high, band pass up to 450 mc. Toroids, magnetic amplifiers, MIL-T-27A transformers. Precision type attenuators. Magnetic components designed to meet customer's specifications.

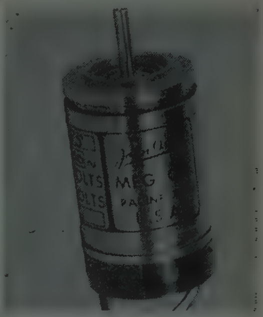
Oryx Company, Booth 4111
13804 Ventura Blvd.
Sherman Oaks, Calif.

Bernard L. Cahn, Jack Fields, Jack Simon, John Nolan, L. K. Ingber, C. H. Mitchell

The only complete line of precision miniature soldering irons. From 6V to 24V, AC, DC. Wgt. ¼ oz. to ¾ oz. For production, services, or laboratory applications. *Model 115-10, 10 watts, 355°C, 110VAC iron uses 3/32" tip. *Model 115-15, 15 watts, 380°C, 110VAC uses 7/32" tip. Approved by Department of Building & Safety, Los Angeles.

John Oster Mfg., Co.
Avionic Division
1 Main Street
Racine, Wis.
Booths 1330-1332

▲ Andrew Barbaccia, Howard Driver, Mort Last, George Lathrop, Jack Pinner, Robert Ramm, Donald Uhen, David Yonis



Hi-Temp Size 8 Synchro

Missile quality components. Newest designs in high and low temperature servos, damped servos, synchros (transmitters, receivers, differentials, control transformers), resolvers, generators, motor tachometers, ac drive motors, dc motors, motor-gear trains, servo torque units, electromechanical assemblies, and indicators.

Oxley Developments Company Ltd., Booth 1820

See: British Radio Electronics Ltd.

Ozalid Division, General Aniline & Film Corp., Booth 4133
Ansco Rd.
Johnson City, N.Y.

Walter Berthold

Ozalid Whiteprint Machines for reproduction of engineering drawings and prints; Machines and Materials for Pre-Printed Wiring Circuits, Diagrams, Production Patterns, etc. Accessories.

PCA Electronics Incorporated
16799 Schoenborn St.
Sepulveda, Calif.
Booth 1333

John Kane, Charles Rubin, Max Shaw, Andrew Jones

Engineering and manufacture of pulse transformers, delay lines and toroids. Stock available on pulse transformers and delay lines. Pulse Transformers: For blocking oscillator, coupling, transistor circuit application to various packaging configurations. Delay Lines: Distributed constant types, lumped constant types, to commercial & military specifications. Toroids: To commercial, military requirements.

▲ Indicates IRE member.
* Indicates new product.

PSP Engineering Co., Booth 2229

See: IMC Magnetics Corp.

Pace Electrical Instruments Co., Booth 3909

See: Precision Apparatus Co., Inc.

Pacific Automation Products, Inc., Booth 4527
1000 Air Way
Glendale 1, Calif.

D. Louro, E. Regan, R. Veloz, E. Heimer, E. Albertson, H. Somer

Custom Electronic Cable, Cable Assemblies and Harnesses, Instrumentation Systems, Control Systems, Electronic Installations, Mobile Mounted Equipment, Special Electronic Devices, Checkout Equipment*, Systems Integration, Communications Systems and Architect and Engineering Services.*

Pacific Division, Daystrom, Incorporated, Booths 1704-1706
9320 Lincoln Blvd.
Los Angeles 45, Calif.

Jack H. Zillman, Bob Wolin, Allan Richards, Joe O'Callaghan, Frank McClure

Precision Wire Wound Potentiometers, Squaretrim Potentiometers, Sub-Miniature Potentiometers, Gyros, Pressure Transducers, Altimeters, Flight Control Systems.

Pacific Semiconductors, Inc., Booths 2742-2744
10451 West Jefferson Blvd.
Culver City, California

S. L. Spiegel, Frank E. O'Brien, Robert T. Reid, ▲ H. N. Sachar, Philip Astra, Thomas Gracie, Cal Tainter, Richard Bossert, Henry DiMond, Hal Nodiff, ▲ John Black

Very High Frequency and Very High Power silicon transistors, High Speed Switching transistors, "Micro-Diodes" and Micro-Transistors. High Q Varicaps (voltage-variable capacitors) and conventional silicon diodes and rectifiers.

Packard-Bell Electronics Corp., Defense & Industrial Group, Booths 3707-3709
12333 West Olympic Blvd.
Los Angeles 64, Calif.

▲ R. B. Leng, ▲ G. Bieging, M. Palevsky, ▲ R. Adams, D. B. White, A. Randazzo, ▲ J. Campbell, H. Miller, ▲ B. L. Soule, ▲ G. Russell, T. Smith, J. Behr

*Multiver M-3: Eleven bit bipolar analog to digital converter—all solid state—approx. 10 KC conversion rate; *DC Differential Amplifier No. 361: 200 KC bandwidth—all solid state including chopper; *Aerotape: Airborne tape recorder-reproducer; ATC Transponder Test Set; *CNI Test Set: Portable, battery operated; RDM Voltmeter; Electromicrometer; *Transducer: High temperature, high line pressure to 800°F.

Paco Electronics Co., Booth 3909

See: Precsion Apparatus Co., Inc.

Page Communications Engineers Inc., A Subsidiary of Northrop Corporation, Booth 3932
Page Communications Bldg., 2001 Wisconsin Ave., N.W.
Washington 7, D.C.

▲ Walter Brehm, ▲ Stuart Hyans, ▲ Donald Palmer, ▲ John Redden, ▲ Arnold Rosenberg, Charles Breeding, ▲ H. H. Schenck, ▲ Ross Bateman, ▲ P. D. Rockwell, ▲ Gail Boggs, ▲ William Collins, J. P. Gaines, Charles A. Parry

Worldwide telecommunications systems: underseas, over the ground, trans-horizon and into space.

(Continued on page 336A)

A complete listing of all registrants at the IRE National Convention and Radio Engineering Show, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

Don't miss this special report at the IRE Show...

NEW DEVELOPMENTS IN HIGH-TEMPERATURE DIELECTRICS

A comprehensive lecture-demonstration
by the engineering staff of Mycalex Corporation of America

Time—3:15 P. M. Daily
Place—FRANCE ROOM
Floor 2M, N.Y. Coliseum
Dates—March 21-24 *(Inclusive)*
Admission—By Invitation ONLY

REGISTER
in advance at
MYCALEX BOOTH
No. 2729-2731

Just a few of the highlights featured at the Mycalex Corporation of America demonstration will include: applications, engineering problems and solutions in high-temperature dielectrics illustrated with special color slides showing:

- **MYCALEX® glass-bonded mica**
- **SUPRAMICA® ceramoplastic**
- **SYNTHAMICA® synthetic mica**

—complete with materials and component samples. This will be followed by a discussion period during which questions will be answered by the Mycalex engineering staff. For your personal invitation, register in advance at the Mycalex booth No. 2729-2731, 2nd Floor, IRE Show.

THE FIRST SYNTHAMICA® SYNTHETIC MICA
THE FIRST SUPRAMICA® CERAMOPLASTIC
SINCE 1919 MYCALEX® THE INSULATOR

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CORPORATION OF AMERICA

General Offices and Plant: 226 Clifton Blvd., Clifton, N. J.
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World's largest manufacturer of glass-bonded mica, ceramoplastic and synthetic mica products

Whom and What to See at the Radio Engineering Show

(Continued from page 334A)

Panoramic Radio Products, Inc.

520 South Fulton Ave.
Mt. Vernon, N.Y.
Booths 3315-3317

B. Schlessel

Spectrum Analyzers from Subsonic thru microwave (0.5 cps to 44000 mc). Response curve tracers from 0.5 cps to 15 mc. FM/FM Telemetry Test Equipment. New 11 point telemetering Calibrator; simultaneous 18 channel output; all transistorized, 7″ high. Improved Single Sideband Analyzer SSB-3a, Broad Band curve tracer, G-6. Unique Microwave Analysis SPA-4, 10 mc-44000 mc.

Parker-Hannifin Corp., Booth 4243

See: Parker Seal Co.

Parker Seal Co., Booth 4243
10567 Jefferson Blvd.
Culver City, Calif.

Frank Opatrny, Don Lee, George Moss, Albert Wickson, Ed Schaub, Jack Watson, Nelson Harway

Standard and special seals for Waveguides and microwave equipment. Seals are reusable, prevent R/F leakage, provide no-leakage mechanical sealing. Also seals for prototype, short production runs, and extreme high temperature and low temperature seals for flanges, fittings and fasteners.

Par-Metal Products Corp.

36-62 49th St.
Long Island City 3, N.Y.
Booths 4302-4304

A. A. Parmet, John Novak, James Berry

Four basic types of slide assemblies of our Universal Cabinet Racks. All Welded Universal Cabinet Racks for 19″, 24″, 30″ Wide Panels, with solid side walls or intermediate side panels, Utility Desk Assemblies.

Pascol Division, Booth 1506

See: Licon Switch & Control Div., Illinois Tool Works.

Penn Engineering & Mfg. Corp.

Box 311
Doylestown, Pa.
Booth 4518

K. A. Swanstrom, B. C. Sandemar, F. Ofner, M. Brenner, J. E. Connard, A. Dorn

Standard Self-Clinching Fasteners and Weld Fasteners. Self-Locking and Self-Clinching Fasteners. Flush external and internal threaded fasteners. *Floating Fasteners. *Midget Self-Clinching Fasteners.

Penta Laboratories, Inc., Booth 2803
312 North Nopal St.
Santa Barbara, Calif.

▲ J. J. Woerner, H. J. Geist, W. L. Hotz

Electron Tubes, Transmitting and special purpose types; beam pentodes and tetrodes, grounded-grid triodes, low-jitter hydrogen thyratrons, vacuum switches.

Perfection Mica Co.

Magnetic Shield Div.
1322 N. Elston Ave.
Chicago 22, Ill.
Booth 4312

▲ Glenn Vance, Glenn L. Powers, ▲ C. M. Jorgensen, ▲ Dave Jones, ▲ John Dreier, ▲ George Harris

Inverted nesting NETIC CO-NETIC cans having slots in side walls permit simple assembly and lead-outs. Slots are positioned so that a minimum opening results on completion, assuring virtually complete magnetic shielding. Configuration minimizes number of layers required.

Perkin-Elmer Corporation

Vernistat Division
Emerald St.
Norwalk, Conn.
Booth 2828

Lionel Robbins, ▲ Lee C. Pulsipher, James F. Balderson, Franklin B. Hutchinson

Vernistat® Precision a.c. Potentiometers—high linearity (to 0.01%) with low output impedance (to 40 ohms), low quadrature (to 0.1 mv/v), and small size (BuOrd Size 11). Vernistat® Adjustable Function Generators (an adjustable nonlinear potentiometer), a.c. or d.c. versions. Vernistat® Variable Ratio Transformers—precision voltage control combined with power output.

Perkin Engineering Corp., Booths 1416-1418
345 Kansas St.
El Segundo, Calif.

▲ Philip Diamond, ▲ Tom W. Lenay, ▲ George W. Mousel, Richard Frink

Magnetic Amplifier Regulated D.C. Power Supplies; Line Voltage Regulators; *Transistorized D.C. Power Supplies Low Voltage High Current Type; *Transistorized Inverters & Converters.

FIRST AID ROOM

A nurse is in charge at all times. First aid room is on the first mezzanine at the north side of the building. Take elevator 20 from any floor.

Pesco Products Division

Borg-Warner Corporation
24700 North Miles Rd.
Bedford, Ohio
Booth M-12

M. W. Nesbitt, R. L. Schroeder, Charles Browning, Mike Redovian, George Ronson, Jack Galbraith, Dan Workman, Robert Montgomery

Static inverters, permanent magnet alternators, thermo-electric generators, axial flow fans, electronic cooling packages, engine-driven generator, electric motors, secondary power systems, auxiliary power systems.

Phaostron Instrument & Electronic Co., Booth 1516
151 Pasadena Ave.
South Pasadena, Calif.

I. W. Eisenberg, H. J. Veitch, Norman Logan

Panel meters, laboratory standards, sensitive relays, test equipment, airborne components.

Pharmaceutical Industries Corp., Booths 2526-2528

See: Electrical Industries.

Phelps Dodge Copper Products Corp.

Inca Manufacturing Division
Fort Wayne, Ind.
Booths 4028-4029

A. F. VanRanst, H. E. Boe, R. Sutman, J. Matthews, C. Frame, Ralph Hall, D. Hilker, J. Burgoon

The world's most diversified line of magnet wire. The only complete line of solderable magnet wires especially for the electronics industry. And, a new mystery wire of unusual interest to manufacturers of motors, coils, and transformers.

Philamon Labs., Inc.

90 Hopper St.
Westbury, L.I., N.Y.
Booth 3111

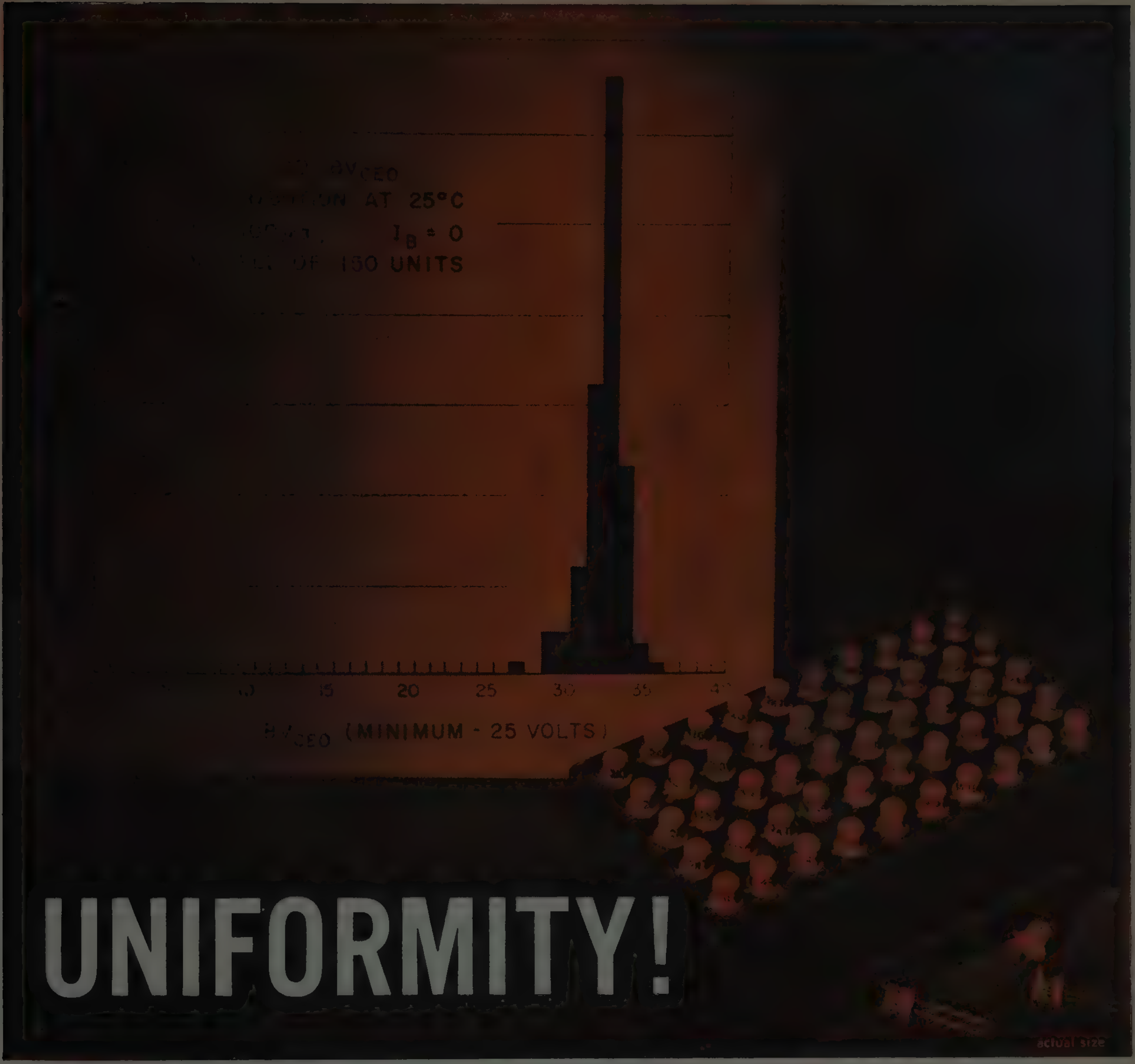
▲ Boris F. Grib, ▲ Robert A. Hunt, ▲ Jack Miller, ▲ Donal F. Gehring

Tuning Fork Controlled Frequency Package

Tuning Fork Frequency Standards—Primary and Secondary—Transistorized Frequency Generators, Binary and Decade Dividers, Signal Amplifiers, Low Power Amplifiers, Oscillator Circuits for missile, aircraft and ground applications.

(Continued on page 338A)

▲ Indicates IRE member.
* Indicates new product.

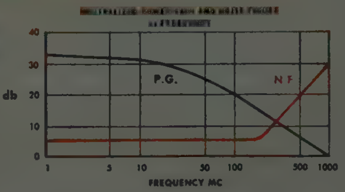


MOTOROLA MESA TRANSISTORS

MOTOROLA 2N700 MESA UHF AMPLIFIER TRANSISTOR

ABSOLUTE MAXIMUM RATINGS

Collector to Base Voltage, V_{CB}	25 volts
Collector to Emitter Voltage, V_{CE}	20 volts
D.C. Collector Current, I_C	50 ma
Maximum Junction Temperature, T_j	100°C
Collector Dissipation Pc (25°C Ambient)	75 mw
Maximum Frequency, fmax	1000 mc
Collector Cutoff Current, I_{CO} typical $V_{CB} = 6V$	0.5 μamp



HIGH FREQUENCY CHARACTERISTICS

Base Resistance, rb′	$V_{CB} = 6V, I_E = 2ma, f = 300mc$	60 ohms	typical
Common Emitter Current Gain, h_{fe}	$V_{CE} = 6V, I_E = 2ma, f = 200mc$	6 db	typical
Collector Capacitance, Cob	$V_{CB} = 6V, I_E = O, f = 100kc$	1.03 $\mu\mu$f	typical

OTHER MOTOROLA MESA TRANSISTORS include: 2N695 world's fastest switching transistor
XN102 world's highest frequency power mesa

Here is graphic evidence of Motorola Mesa uniformity. Data is typical of that compiled on random samples from all production lots.

The remarkable uniformity of Motorola Mesa transistors means greater reliability . . . simplified circuit design through better balanced devices . . . more reliable circuits. Uniformity also means availability. Because of the unique features of Motorola Mesa transistors, each production line produces only one device . . . not a series of similar devices. This enables Motorola to achieve volume production of these sophisticated devices.

FOR TECHNICAL AND APPLICATIONS INFORMATION contact your Motorola Semiconductor district office, today!

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Semiconductor Products Division

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1051 Bloomfield Avenue
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13131 Lyndon Avenue
BRoadway 3-7171

CHICAGO 39, ILLINOIS
[illegible] West Diversey Avenue
AVenue 2-[illegible]

MINNEAPOLIS 27, MINNESOTA
7731 6th Avenue
LIberty 5-2198

HOLLYWOOD 28, CALIFORNIA
1741 Ivar Avenue
HOllywood 2-0821

Whom and What to See at the Radio Engineering Show

(Continued from page 336A)

Philco Corp.
Lansdale Tube Co. Div.
Church Road
Lansdale, Pa.
Booths 1302-1308

▲ W. J. Peltz, ▲ C. H. Warshaw, W. F. Maher, M. J. James, ▲ S. L. Levy, ▲ C. S. Simmons, ▲ C. I. Swanson, K. E. Schubert, ▲ E. S. Eisenscher, J. J. McCartin, J. Kindregan, W. Brydia, D. E. Reynolds, P. S. Armstrong, E. W. Bobigan, A. Berry, M. L. Snyder, J. W. Mintzer

Philco's high-power, high-speed Micro-Alloy Diffused Base (MADT*) transistors, complete transistor line. Millimeter Diode* and others. IR Detectors. Panorama of complete communications system with semiconductors; radar, ground control, computers, missile tracking gear. Working 'scope shows H-P MADT switch performance in circuit.

Philco Corp., Booths 3031-3032

See: Sierra Electronic Corporation.

Philips Electronics, Inc., Booths 2522-2530

See: Amperex Electronic Corp., Electrical Industries, Ferroxcube Corp. of America.

Phillips Control Corp., Booth 2340
59 W. Washington St.
Joliet, Ill.

Merle Hayward, W. R. Baughman, Ralph Nieland, J. Rowell, ▲ H. H. Hartong, Bill Facinelli, ▲ Bill Reagan, Don Schofield, Harry Buys, Dick Smego

Quality Relays for—Aircraft; Multi-contacts featuring longer life; Power & General Purpose; Solenoids; See new Crystal Can & Versatile Telephone Types; Hermetic Seals of All Types; Check unique Phillips Dependability in products, engineering & Service!

Photocircuits Corp., Booths 2201-2203
31 Sea Cliff Ave.
Glen Cove, L.I., N.Y.

H. I. Rudman, ▲ J. Calpena, ▲ F. Beste, ▲ R. L. Coryell, ▲ S. Hudson, ▲ A. W. Kelly, ▲ J. M. Knizeski, ▲ S. H. McVicar, ▲ P. L. Ross, ▲ C. J. Saffery

Conventional and miniaturized printed wiring boards utilizing Tuf-Plate plated-through hole design. Proto Division offers fast delivery service for prototype and sample quantities. Printed circuit motors photoelectric tape readers, master circuit design technique, ceramic printed circuit.

Physical Sciences Corp., Booths 3707-3709

See: Packard-Bell Electronics

Pic Design Corp., Booth 1625
477 Atlantic Ave.
East Rockaway, L.I., N.Y.

Winfred M. Berg, Rowland F. Schwenker, P. J. Wellenberger, John L. Swane, Charles Keenan, Herman Hering, Jack Bradley, William Swane, Walter Caverno

Precision 2 and 3 gears from stock. Precision Breadboard & Development Components: Instrument Plates, Bevel Gear Boxes, Magnetic Clutches, dials, Differentials, shafts, Tool Parts, etc. *Just Released anti-backlash worm wheel and Zero Adjustable Bellows Coupling.

MORE DATA

Exhibitors shown in boxed listings, or with product illustrations, have more data for you in their advertisements in the March 1960 issue of "Proceedings of the IRE."

Pickard & Burns, Inc., Booth 3044
240 Highland Ave.
Needham 94, Mass.

▲ I. J. Metcalfe, ▲ F. C. Leiner, ▲ M. N. Arlin, ▲ M. F. Spears, ▲ J. J. Glynn, ▲ T. C. Cahill, S. L. Smith, ▲ L. D. Shapiro, J. C. Williams

Research, Development and Manufacturing in the fields of Radio Communications and Navigation Systems, Instrumentation and Antenna Systems. A new Radio Locked Frequency Standard (RALOC); Temperature Monitoring Equipment.

Pitometer Log Corp., Booth 3024
237 Lafayette St.
New York 12, N.Y.

Bernard Kahn, D. J. Kreines, ▲ Norman Sturm, ▲ R. C. Rosaler, Rudy Volhard, Ed Bleistein, ▲ Gordon Silversmith, ▲ Ed Wrobel, Michael Smolin, Bill Hallock

*Series 800 Stalo Tester with L, S and X-Band Tuning Units. Tunable Stalos Covering *UHF, L, *S and X Microwave Frequency Bands, With Stability of 5 Parts in 10^9. Also Xtal Chain Stable Local Oscillators. High Temperature Transistorized Controls.

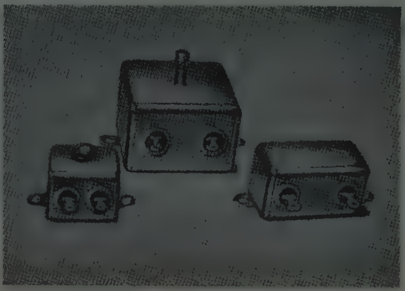
Pittman Electrical Developments Co., Booth M-21
Sellersville, Pa.

Charles A. Pittman III, William G. Blacklock

Miniature low voltage permanent magnet field direct current motors.

Plastic Capacitors, Inc.
2620 N. Clybourn Ave.
Chicago 14, Ill.
Booth 2740

Stephen Meskan, Harold Francis, Robert Curtin, Richard Henry, Richard A. Strassner, Merrill Holt, Dave Dolin

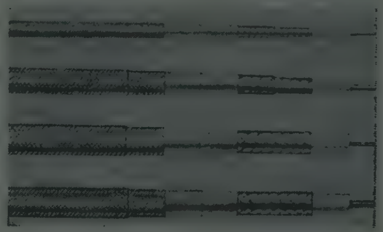


*New close tolerance polystyrene, *high reliability paper-mylar and *high package density metallized mylar capacitors. Mylar, polyethelene, teflon, and paper dielectrics exceeding MIL requirements. Pulse Forming Networks, 60 and 400 CPS input low current, high voltage power supplies, *low cost impedance comparison bridges.

Be sure to see all four floors for a complete view of 800 new ideas!

Plastoid Corporation
42-61 24th St.
Long Island City 1, N.Y.
Booth 4525

W. Grant, D. J. Nichols, Dean Haggerty, Milton Weinschel, A. W. Anderson, ▲ Leon J. Brodsky, Warren Moffett, C. Myslinski, E. H. Cooper, ▲ Jerry Tomey, T. E. Gaess, Toby Del Guidice

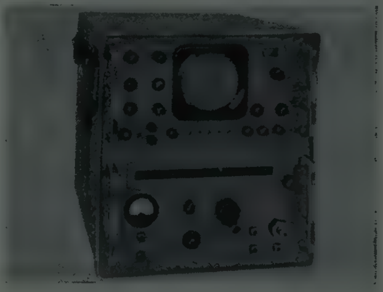


Teflon Coax Cables

Specifications of wire & cable constructions for hook-up, power communication and control, aircraft, coaxial cable, seismograph cable, gun control, atomic energy, score board, switchboard, underwater sound, airport control, electronic instruments, power cable per IPCEA Spec., kite cable, shipboard cable, special constructions.

Polarad Electronics Corp.
43-20 34th St.
Long Island City 1, N.Y.
Booths 3205-3211

A. A. Goldberg, R. J. Sheloff, R. Savold, R. Saul, P. H. Odessey



Universal Spectrum Analyzer

Model SA-84W Universal Spectrum Analyzer capable of precisely measuring all microwave parameters; Model RW-T Antenna Pattern Microwave Receiver—frequency range 2 to 75 kmc with single tuning head. Complete line microwave signal generators, spectrum analyzers and receivers. Information available on Polarad's Mobile Field Laboratories and Demonstrator.

Polyphase Instrument Co., Booth 2839
East Fourth St.
Bridgeport, Pa.

E. C. Capuzzi, D. J. Seifert, A. M. Meyer, E. Bard, R. F. Adams

Pulse, Audio, Toroidal, Converter, Specialty Electronic Transformers, Electrical Wave Filters, Inductors, Delay Lines, Modules* and Special Magnetic Components for Military and Industry. Static and Dynamic Strain Measuring Instruments and Accessories. Internally Strain-Gaged Transducers, Load Sensitive Bolts. *New group of standard Lumped Constant Delay Networks.

Polytechnic Research & Development Co., Inc.
202 Tillary St.
Brooklyn 1, N.Y.
Booths 3602-3606

▲ H. C. Nelson, ▲ M. Wind, ▲ P. Mariotti, ▲ L. H. Fisher, D. Cooper, W. A. Weissman

"Pacemaker" line of Microwave & Electronic Test Equipment. *Klystron & BWO/TWT Power Supplies. *Slotted Sections, *Variable & Fixed Attenuators, Sliding Shorts, Standard Mismatches, Sliding Terminations, Rotary Standing Wave Indicators, Bolometers & Thermistor Mounts, Frequency Meters, *Standing Wave Amplifiers, Power Bridges, Calorimeters, etc.

(Continued on page 340A)

only Grant could design the cost-conscious BUDGETEER

Only Grant's wide experience as the leading manufacturer of slides could yield the know-how needed to produce the Budgeteer! *The first low cost chassis slide with features found only in the most expensive slides.*

If your product or product-to-be must be designed or fabricated to a cost-conscious appropriation, you'd be wise to check the Budgeteer's features—features that can put the most advanced maintenance-efficiency ratings on the most modest budget jobs.

full extension • parts interchangeability • quick-disconnect • low cost • ball bearing action • 150 lb. load capacity

Write for complete literature & prices.

The nation's first and leading manufacturer of slides

GRANT INDUSTRIAL SLIDES

GRANT PULLEY & HARDWARE CORPORATION

43 High Street, West Nyack, New York
944 Long Beach Avenue, Los Angeles 21, Calif.

Whom and What to See at the Radio Engineering Show

(Continued from page 338A)

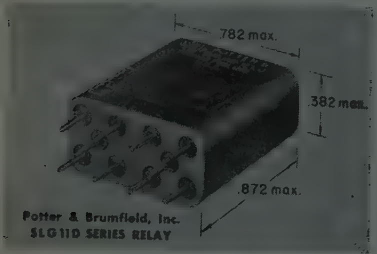
Popper & Sons, Inc., Booth 4124
300 Fourth Ave.
New York 10, N.Y.

Walter L. Popper, Robert A. Popper, R. G. Illner, L. J. Heller

Marking Equipment—hand operated, semi-automatic, and fully automatic. Color-Banding machines.

Potter & Brumfield, Inc.
Div. of American Machine & Foundry Co.
Princeton, Ind.
Booths 2702-2704

T. B. White, James Rudy, Nelson Havill, M. J. Kelly, ▲ Z. R. Smith, H. L. Huntsinger, J. V. Foster



SLG 11D Series Relay

Complete line of micro-miniature, power, sensitive, general purpose, special purpose and telephone type relays.

Potter Instrument Co., Inc., Booths 3407-3409
Sunnyside Blvd.
Plainview, L.I., N.Y.

▲ Edward D. Gray, ▲ George Comstock, ▲ R. Schramm, ▲ W. Jennings, ▲ J. Richardson, ▲ A. Gabor, ▲ G. Newberg, ▲ R. Mahland, ▲ C. Wassermann

*Transistorized high speed digital tape transport Model 906 II and amplifiers, high speed printers, *MIL Paper Tape Programmer Electronic Counters, Magnetic and Photoelectric Heads, Perforated Strip Reader.

Power Designs Inc.
1700 Shames Drive
Westbury, L.I., N.Y.
Booth 2104

▲ M. Geller, A. Silver, H. Roth, S. Gordon, G. Rotundi, R. Sterman, S. Hochman, P. Nurches, J. Lightstone, J. Boscov

Model 3240 Transistorized Power Supply

Semiconductorized power supplies utilize the unique properties of semiconductor devices to create new circuit concepts achieving performance, efficiency and reliability hitherto unattainable. These instruments are not the conventional transistorized versions of vacuum tube regulators.

▲ Indicates IRE member.
* Indicates new product.

Power Sources, Inc., Booth 1914
South Ave.
Burlington, Mass.

▲ Jon B. Jolly, ▲ Stanley N. Golembe, ▲ Robert Smyth, ▲ V. J. Huntoon

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Oscilloscopes, Tube Testers, VTVM, AF-RF Signal Generators, TV Marker Bar generator, Power Lab, Voltage Regulator Power Supply, Decade Boxes, Probes, Transistor kits, AM-FM Tuners, Low cost high efficiency Stereo Amplifiers. Transformers & Coil Components.

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PRECISION Electronic Testing Instruments, PACE Panel Meters, PACO Electronic Equipment Kits. Cathode Ray Oscilloscopes, Signal Generators, VTVM's, V-O-M's, Vacuum Tube Testers, Transistor Testers, Rand C Decade Boxes, Industrial Circuit Testers, Sine-Square Wave Generators, Stereophonic Preamp-amplifiers, Stereo AM/FM Tuners.

Precision Instrument Company, Booth 3035
1011 Commercial St.
San Carlos, Calif.

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Chicago 47, Ill.

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See: Bogen-Presto Co.

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(Continued on page 342A)

Where can I find it?

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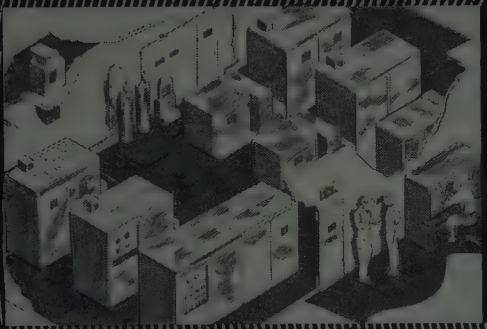

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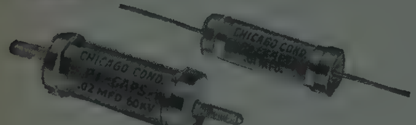
TYPE	OUTPUT VOLTAGE	MA	SIZE	WEIGHT
251 NR	2 KVDC	5	2½ x 3¾ x 3⅜	2.75#
551 NR	5 KVDC	5	2½ x 3¾ x 3¾	3.25#
1051 NR	10 KVDC	5	3¾ x 4 9/16 x 6½	8# 10 oz.
1551 NR	15 KVDC	5	3¾ x 4 9/16 x 6½	9# 10 oz.

2 TYPE PAS CAPACITORS BUILT FOR RUGGED DUTY



Heavy wall Pyrex glass with metal end caps. With the glass case serving as insulator, this is a light weight and compact unit with high capacity per volume at high voltages. Standard and extended temperature ranges.

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WRITE FOR LITERATURE

CHICAGO CONDENSER CORPORATION
3255 W. ARMITAGE AVE., CHICAGO 47, ILLINOIS

Whom and What to See at the Radio Engineering Show

(Continued from page 340A)

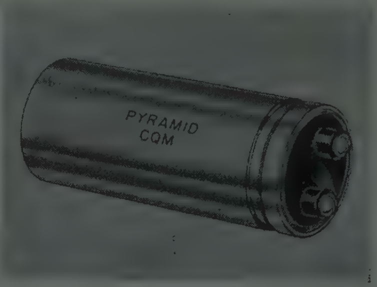
Pyle-National Co., Booth M-4
1334 North Kostner Ave.
Chicago 51, Ill.

▲ H. F. Whalen, Jr., J. F. Shearer, L. J. Milewicz

Manufacturers of environmental and miniature electrical connectors for power, control, electronic and thermocouple circuits.

Pyramid Electric Company
507-26th St.
Union City, N.J.
Booth 1311

R. Scorano, M. A. DeMatteo, J. Starr, ▲ R. Lane



Computer Type Electrolytic Capacitor

Capacitors fixed; electrolytic, paper, metallized paper, Mylar, tantalum; capacitors manufactured to military specifications. Specializing in subminiature and computer-quality capacitors.

Pyrofilm Resistor Co., Inc., Booth 2235
U.S. Highway 46
Parsippany, N.J.

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Pyroseal—high stability fusion sealed, carbon film resistors for high precision networks, ultra temperature resistors, MIL carbon film resistors, traveling wave tube attenuators, flat plate wave guide attenuators, rod and disc high frequency attenuator elements. Custom Designs.

Pyrometer Co. of America, Inc., Booth 3017

See: Magnetic Instruments Co., Inc.

Quan-Tech Laboratories
60 Parsippany Blvd.
P.O. Box 187
Boonton, New Jersey
Booth 3034

▲ John M. van Beuren, Alan P. Stansbury, Fred R. Stampfli, ▲ Ronald C. Pittenger, Richard M. Conrad, Richard A. Struble

milliamperes

Model 151 Constant Current Supply

*Specialized Noise Test Sets, *Instrumentation Amplifiers, *Constant Current Power Supply, Transistor Regulated Power Supplies, AC Microammeter, Wave and Noise Spectrum Analyzer, DC Coupled Decade Amplifier, Differential or Isolation Amplifier, Specialized Test Equipment and Power Supplies built to Customer specifications.

REF Manufacturing Corp., Booth 4327
393 Jericho Turnpike
Mineola, L.I., N.Y.

J. Simon, H. Maron, A. J. Fiori, R. Gordon, F. Quitoni, A. R. Willis, Jr., M. Rochman

Research, Engineering Fabrication of metal and reinforced plastic assemblies, cabinets, consoles, transit cases, shelters. *Hydraulic, Electro-Mechanical, Electronic Test and Ground Support Equipment designed and built to specification. Military Spec. and Airborne requirements assured by experience and precision quality control.

R & S Electronic Sales Corp., Booth 4233

See: Technical Devices Co.

RS Electronics Corp., Booth 2738
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Palo Alto, Calif.

▲ Robert K.-F. Scal, ▲ Albert B. Worch, ▲ Clinton O. Lindseth, ▲ John Isabeau

*Command Receiver (transistorized), *Transistor I.F. Amplifier, *(1-500 MC) Distributed Amplifier, IF-RF Amplifiers, Converters, UHF Receivers, Modulators, *AC or Battery (Failure Proof) Power Supply.

Radar Measurements Corp., Booth 3005
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Hicksville, N.Y.

Meredith McBride

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Radiation Incorporated, Booth 3004
Melbourne, Fla.

F. Fernety, L. P. Clark, Jr., W. W. Dodgson, Jr., Grady Hartzog, C. J. Underwood, Jr., John Boswell, Dom Casale, Jack Petersen, H. Trenner, ▲ C. H. Hoeppner

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See also: Levinthal Electronic Products, Inc., Booth 3003

Radio Corporation of America, Booths 1602-1608, 1701-1707
Defense Electronic Products
Camden, New Jersey

J. R. Dunn, W. H. Hahn

Military Electronic Equipment.

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Electron Tube Department
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* Indicates new product.

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Long Island City 1, N.Y.
Booths 1202, 1301-1303

▲ F. A. Gunther, J. R. Day, H. Sadenwater, M. Kraus, ▲ G. Papamarcos, T. P. Rizzuti, ▲ H. H. Robinson, D. F. Koijane, A. Waxman

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Radio Frequency Laboratories, Inc., Booths 3115-3119
Powerville Rd.
Boonton, N.J.

J. M. Janicke, R. E. Crocetti, R. H. Denton, H. H. Emker, R. M. Treible, R. J. Gilman

*Precision AC/DC Instrument Calibration Standards; Magnet Charging Treating and *Measuring Equipment; *Variable Frequency Power Supplies; *Crystal Impedance Meter; *Transistorized Telemeter Tone Terminals and Accessories.

Radio Materials Co.
Div. of P.R. Mallory & Co., Inc.
3325 N. California Ave.
Chicago 18, Ill.
Booth 1414

▲ Fred Spellman, ▲ Wally Swank, ▲ Henry Lavin, Jack Benz, ▲ Tony Wahl, Joe Baxter, Jack McVity, Jules Kornberger, Harry Byrne, Jack Glynn, Dick Bourgerie, Bob Merritt

Ceramic Discap Capacitors—Temperature Compensating—By-Pass—Temperature Stable—High Voltage—Frequency Stable—Transistor Type Capacitors.

Radio Receptor Company, Inc., Subsid. General Instrument Corp., Booth 1218-1224
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Brooklyn 11, N.Y.

Arne Nash, Julian Loebenstein, Seymour Winuk, Chet L. Schuler, Vincent Griski, Arthur Witz, Frank Lavelle

TRI-AMP selenium rectifiers—unlimited life expectancy; subminiature selenium diodes; high voltage cartridge rectifiers; electronic rectifiers; contact protectors; entertainment rectifiers; special selenium rectifier 'Flats'; DC blocking rectifiers.

Ramo-Wooldridge Div., Booths 1431-1631

See: Thompson Ramo Wooldridge, Inc.

Rawson Electrical Instrument Co., Booth 3313
118 Potter St.
Cambridge 42, Mass.

M. J. Lush

*New line of DC to 100 MC RF Voltmeters, Rotating Coil Gaussmeters, Electrostatic Voltmeters, Peak Voltage Rectifiers, Wattmeters, Thermal Meters, Multimeters®, Fluxmeters, Dynamometer Type Meters, Microammeters, Millivoltmeters, Milliammeters, Panel Mounting Meters.

Raybestos-Manhattan, Inc., Asbestos Textile Div., Booth 4014
Manheim, Pa.

J. A. Bettes, Jr., J. A. Brown, Jr., H. H. Herr, Jr., M. Q. Scowcroft, D. B. Skillin, C. A. Williams, Jr., R. L. Witmyer

TEFLON—Sheet, Rods, Tubes, Skived Tapes, machined and molded parts. ASBESTOS—Roving, Lap, Yarn, Cable Filler, and Insulating Tapes.

(Continued on page 344A)

See
Ultrasonic Welding
of
Electronic
Components

Booth 4238
IRE Show

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CRYSTAL OSCILLATOR
with transistorized,
proportional-controlled oven
see it at I.R.E. Show
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REEVES-HOFFMAN
DIVISION OF DYNAMICS CORPORATION OF AMERICA
CARLISLE, PENNSYLVANIA

Whom and What to See at the Radio Engineering Show

(Continued from page 343A)

Raytheon Company, Commercial Apparatus & Systems Division, Magnetic Operations, Booths 2610-2614
190 Willow St.
Waltham 54, Mass.

J. J. Eibye, J. E. Vielehr, R. C. Peterson, W. G. Stephens

Hermetically sealed, encapsulated, and fluorochemical pulse and power transformers.

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Commercial Apparatus & Systems Division
Production Equipment Operations
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W. Nicholson, W. Sharpe, T. Auger, G. Zipf, R. Curtis, B. Stuart, A. Morrill, R. Foote, P. Sorenson, J. Kelly, P. Duran

PF Voltage Regulating Transformer

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Raytheon Company
Industrial Components Division
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Booth 2610-2614

F. Schillinberg, R. Knowles, W. Greer, R. Gates, G. Caudell, W. Cronburg, W. H. Weed, E. H. Clark

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Raytheon Company, Machlett Laboratories, Inc., Booths 2604-2614

See: Machlett Laboratories, Inc.

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Waltham 54, Mass.
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QKB 760A Backward Wave Oscillator

Amplitrons®, high-power klystrons, high-power traveling wave tubes, OEM type backward wave oscillators, Monifier, IR detector, magnetrons, low-power klystrons, low-power traveling wave tubes.

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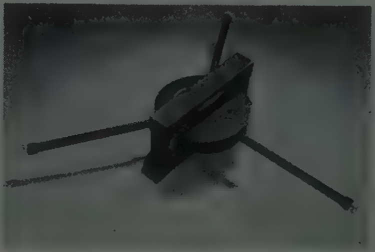
Special Microwave Devices Operations
100 River St.
Waltham 54, Mass.
Booths 2610-2614

▲ J. Stabile, ▲ R. Moschella, B. Hasch, ▲ Dr. H. Scharfman, ▲ Dr. C. Bowness, ▲ J. Owen, ▲ W. Vafiades, A. F. White



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Complete line of microwave ferrite devices from UHF through K band, such as isolators, circulators, switches and modulators, in a wide range of power handling capacity and frequency coverage.

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Booths 2610-2614

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PNP and NPN silicon transistors, PNP and NPN germanium transistors, subminiature germanium and silicon transistors, silicon rectifiers, bonded silicon diodes, gold bonded and point contact germanium diodes, Circuit-Paks.

Raytheon Company, Sorensen & Co., Inc., Booths 2604-2606

See: Sorensen & Co., Inc., Subsid. Raytheon C

Reeves-Hoffman Div.
Dynamics Corp. of America
Cherry & North Sts.
Carlisle, Pa.
Booth 1309

Heinz J. Kammin, Arthur R. Muller, Carroll M. Rahn, George E. Spease, Richard L. Van Gavree.

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Frequency Source, transistorized, 60 Cps to 100 Mc. Illustrated above is timing generator providing 2 square wave and 2 pulses at repetition rates of 400, 500 and 1000 Cps. Rise times less than 1 microsec.; temperature range —55°C to +65°C. Timing accuracy of 3 parts in 10^6.

Reeves Instrument Corp., Subsid. Dynamics Corp. of America, Booths 1305-1307
East Gate Blvd., Roosevelt Field
Garden City, L.I., N.Y.

A. Chase, J. Gavin, I. B. Goldberg, J. Gotthelf, J. Z. Kunze, A. F. LaBarbara, C. Lax, P. I. Rafield, G. H. Steinberg, M. Travers

*Antenna Pedestals, Guidance Computers, *Modular Transistorized Amplifiers, Gyros, Gyro Test Tables, Induction Resolvers, *Data Transmission Resolvers, Servo-Mechanical Components, REAC® Analog Computers, Stable Platforms.

Reeves Soundcraft Corporation, Booth 1327B
Great Pasture Rd.
Danbury, Conn.

William H. Deacy, William A. Morrison, Robert A. Schlicht, Edward F. Claffey, Peter W. Hill, Stuart D. Draudt

Magnetic recording tapes and accessories for all applications including amateur and professional sound recording, video recording and the instrumentation uses of computers, telemetry, and numerical control.

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Boston 18, Mass.
Booth M-6

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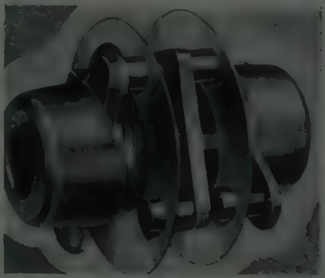

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(Continued on page 346A)

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Whom and What to See at the Radio Engineering Show

(Continued from page 344A)

Reon Resistor Corp.
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Yonkers, N.Y.
Booth 1926

▲ Leon Resnicow, J. J. McCann, Eugene V. Mandel, Mortimer Lazarus, Eric Maneskjold

Molded Composition Variable Potentiometers per MIL-R-94B, Types RV4, RV5, RV6, meet all applicable specifications. Fixed Precision Wire Wound Resistors meet MIL-R-93B. Precision Resistance Networks. Micro-Miniature Precision Resistors.

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Special Products and Service Div.
Farmingdale & Springdale, L.I., N.Y.
Booth 3936

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Rex Corp., Booths 4306-4310
See: William Brand—Rex Div.

Rheem Semiconductor Corp.
327 Moffett Blvd.
Mountain View, Calif.
Booths 2925-2926

J. D. Hurley, ▲ R. Maravich, ▲ G. Schontzler, J. Gattuso, F. Breene, A. Dixon, C. Schumacher, J. Hughes, H. Weyrick, E. Chiswell

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Double Diffused Silicon Mesa Transistors: High speed switching, medium and high power types. Glass Package Silicon Diodes: General purpose (JAN types), fast switching (Signal Corps types), low power rectifiers and special assemblies of matched units.

Richards Electrocraft, Inc., Booth 2126
See: G-C Electronics Mfg. Co.

John F. Rider Publisher, Inc.
116 W. 14th St.
New York 11, N.Y.
Booth 4516

▲ John F. Rider, Jerome Kass, D. H. Gieb, Wm. J. Marcus, Marvin Garfinkel, Cynthia Stevens, Jack Greene, Norman Cohen, J. Schneider

Publishers of Texts and Manuals on Electricity, Electronics, Computers, Physics, Space and Nuclear Age, and Allied Sciences.

Riggs Nucleonics, Booth 3018
See: ELIN Division.

Rixon Electronics, Inc.
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Silver Spring, Md.
Booth 3411

▲ J. L. Hollis, ▲ C. J. Harrison, ▲ J. C. Myrick, D. W. Perry, M. F. Frank

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Design-Development-Assembly of Communications Oriented Equipment: 500 to 5000 Baud-Data Transmssion Equipment for 3 KC Voice Lines, 16-Channel TTY MUX, Transistorized Relays, Envelope Delay Equalizers, Special Filters—Fixed and Tunable, RF Systems—Low Noise Preamplifiers to High Power Transmitters.

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▲ Lee J. Colbert, Norman H. Brown, H. Lefcowitz

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Cables and harnesses, molded cables, glass hermetic sealing, molded components, power line and communications—vinyl splice cases and vinyl connector cases, custom-built connectors, panels and switch gear.

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Booths 2506-2508

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Electronic measuring instruments & communications equipment, Frequency* & Time* Standards, Signal Generators* 250-2750 mc 20 watts, Selective Microvoltmeters type USVH* 10 kc to 30 mc Frequency *Synthesizer and exciter 2-30 mc type No. 261 synthesizer*. Impedance measuring devices: bridges, diagraphs, tune null detectors, Multicouplers*, FM-Relay Receivers*, Communications Receivers*, POLYSKOP.

Roller-Smith Division, Booth 2338
See: Fifty Avenue L, Inc.

Rosan, Inc., Booth 4016
2901 West Coast Highway
Newport Beach, Calif.

A. Eckert, H. Baynton, G. Jones, A. Redlitz, B. B. C. Lovett, J. Mills, E. G. Miller, J. Rosan, Sr., R. L. Gibney

Floating press nut, and press terminals, two world exclusives for space, missile, aircraft and electronic industries. High reliability, characteristic of all Rosan products, is assured by these fasteners designed for today's extreme environmental requirements.

(Continued on page 348A)

KENNEDY'S NEW SPINCASTING PROCESS...

has the IRE Show in a whirl... Better visit Booths 2532 and 2637 and find out how this breakthrough in antenna technology can help you.

D.S. KENNEDY & CO.

ANTENNA DIVISION
Cohasset, Massachusetts
Telephone: EVergreen 3-1206

ADVANCED ENGINEERING DIVISION
P.O. Box 1711 Monterey, California
Telephone: FRontier 3-2461

ANCHOR METALS DIVISION
P.O. Box 148 Hurst, Texas

"SPOOLY" SAYS

ANOTHER FIRST For SUPER-TEMP

UL APPROVED TEFLON* WIRE!

Super-Temp . . . always first with the finest . . . now offers Underwriters' Laboratories label service on appliance wiring material for standard "Type E" Teflon insulated hook-up wire. Super-Temp's U. L. approved wire offers 5 big advantages.

1. Small Diameters — 10 mil wall thickness
2. Wide Range of Sizes
3. High Temperature Protection
4. Soldering Protection
5. Chemical Resistance

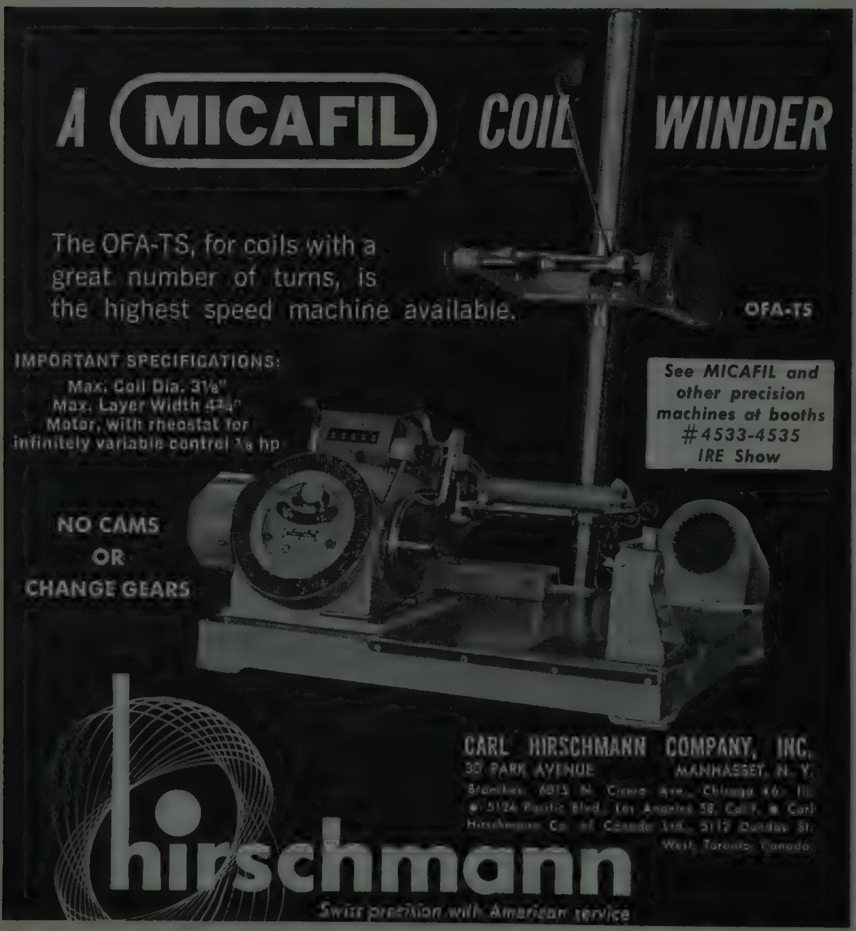
*DUPONT'S TFE RESIN

Ask us about it at the IRE show, Booth No. 4416.

Save Time WITH Super-Temp

American Super-Temperature Wires, Inc.
West Canal Street, Winooski, Vermont • UNiversity 2-9636
General Sales Office: 195 Nassau St., Princeton, N. J. • WAlnut 4-4450
A Subsidiary of Haveg Industries, Inc.
See us at the IRE Show—Booth #4416

Free! Send for 1960 Catalog. 88 pages of valuable data.


A MICAFIL COIL WINDER

The OFA-TS, for coils with a great number of turns, is the highest speed machine available.

OFA-TS

IMPORTANT SPECIFICATIONS:
Max. Coil Dia. 3⅛"
Max. Layer Width 4¾"
Motor, with rheostat for infinitely variable control ⅛ hp

See MICAFIL and other precision machines at booths #4533-4535 IRE Show

NO CAMS OR CHANGE GEARS

CARL HIRSCHMANN COMPANY, INC.
30 PARK AVENUE MANHASSET, N. Y.
Branches: 6015 N. Cicero Ave., Chicago 46, Ill. • 5124 Pacific Blvd., Los Angeles 58, Calif. • Carl Hirschmann Co. of Canada Ltd., 5112 Dundas St. West, Toronto, Canada.

hirschmann
Swiss precision with American service

Whom and What to See at the Radio Engineering Show

(Continued from page 346A)

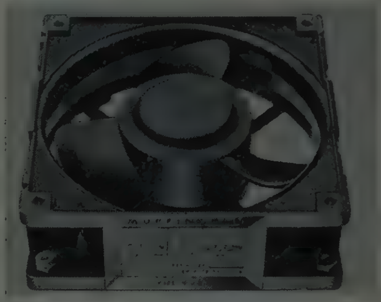
Rotating Components, Inc., Booth 1234
267 Green St.
Brooklyn 22, N.Y.

N. F. Giarra, A. G. Miller, J. H. Mills, G. Sprinsky

Inverted Blowers—cool running, compact, long life, high pressure. Mil spec ac motors, blowers, axial fans, tube & vane axial fans; cooling cabinets, servo motors, gearmotors, generators. 1/2000 to ¼ h.p., 1" to 3⁹⁄₁₆" OD, low & high temp, variable & single freq., 50 to 1000 cps. Stock or custom.

Rotron Mfg. Co.
7-9 Schoonmaker Lane
Woodstock, N.Y.
Booths 2830-2832

▲ J. C. van Rijn, P. M. Beard, J. C. Larson, D. Carlson, W. W. Blelock, Jr., F. Desmond, H. E. Huber, J. P. Cerasaro, P. S. Lyon, A. Gran, L. Sima, E. N. Goddard, M. Edwards, G. M. Taylor



Muffin Fan

Complete line of cooling devices for ground, shipboard, aircraft and missile applications. Specialties include: (1) Family of miniature, high speed 400 CPS fans, (2) Designs for high pressure or vacuum up to 70" W.G., (3) Commercial fan 5" square which will deliver 100 CFM free delivery.

Rowan Controller Co., Booth 2130A
2313-2315 Homewood Ave.
Baltimore 18, Md.

S. M. Becker, A. Wehrung, R. Dalton, G. C. Ellis, J. C. Ellis, A. L. Haskell, Jr., M. C. Johnson, P. G. Eaton

Introducing a line of panel meters, 1% accuracy, multitesters, transistor-meters, megohmmeters, and instruments. Versatile and compact magnetic contactors and circuit protectors for the computer and electronic industry.

Rubicon Div., Booth 2210
See: Minneapolis-Honeywell.

Rutherford Electronics Co., Booth 3834
8944 Lindblade St.
Culver City, Calif.

▲ C. E. Rutherford, ▲ Howard E. Mette, Stan Schwartz, ▲ N. T. Holzer

Introducing the new Model B7-B, 20 cps to 2 megacycle high utility, low cost, pulse generator. Also shown will be the Rutherford Model B5-2 10 megacycle double pulse generator combining high frequency repetition with extremely fast rise time.

Rye Sound Corp., Booth 2933
See: Richard Hirschmann Radiotecnisches Werk

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 21-24, 1960

Sage Electronics Corp.
Country Club Road
Rochester, N.Y.
Booth 2236

F. Dwight Sage, Davidge H. Rowland, Allen P. Mills, ▲ J. C. Van Arsdell

Sage Resistors

Miniature precision wire wound resistors; power ratings from 1 to 50 watts; tolerance from 5% to .05%; Sage "Clipper" clip mount heat sink resistors. Introducing this year a non-inductive line and resistors manufactured to surface requirements of military characteristic V.

Sage Laboratories, Inc., Booth 1910
3 Huron Drive
East Natick Industrial Park
Natick, Mass.

G. A. Ayoub, J. A. Camuso, ▲ J. J. Chacran, W. J. Kennedy, E. W. Lattanzi, ▲ T. S. Saad, J. M. Shalhoub, ▲ R. Tenenholtz

*Stripline Hybrids, *Coaxial Directional Couplers, Cobrids, *Balanced Mixers, Rotary Joints, Slotted Lines, Crystal Holders, Isolators.

Howard W. Sams & Co., Inc., Booth [redacted]
2201 East 46th St.
Indianapolis 5, Ind.

J. A. Milling, W. D. Renner, B. C. Landis, L. H. Nelson, G. Mowry, T. G. Shonfield.

Specialized Services and instruction manuals, maintenance and operating data, Product Catalogs, Engineering Analysis, Product Testing, Training Materials, Direct Mail Services, Technical Writing, Technical Compilation, Art and photographic services, printing facilities, PHOTOFACT Folders, PF Reporter, Tube Facts.

San Diego Scientific Corp., Booth 3930B
3434 Midway Drive
San Diego 10, Calif.

▲ David C. Kalbfell, John W. Bodnar, John J. Chaparro, ▲ Philip Wasserman

Magne-Plexer®, low level solid state commutator for millivolt signals. Operates at 6000 samples per second, available practically any number of inputs. Floating inputs provide common mode rejection in order of 135db. Output 5 volts, typical accuracy of 0.2%. Signal circuits not switched; programming readily changed by plug-in cards.

San Fernando Electric Mfg. Co., Booth [redacted]
1509 First Street
San Fernando, Calif.

Alan Rubendall, Michael Rosenberg, Jerry Ciral, Lyle R. Smith, Donald E. Rubendall, Eileen Johnson, Helen Jensen, Gene Bell, Kermit Hawkins, William Gutknecht

WEST-CAP CAPACITORS: High Reliability, MIL C 14157A; Paper Dielectric, MIL C 25A; Mylar Dielectric, Polystyrene Dielectric, Teflon Dielectric, Metallized Paper, Metallized Mylar—all Hermetically Sealed; Feed-thru Capacitors; Rap-n-Fil commercial grade capacitors—Mylar, Polystyrene, Metallized Paper. Also, General Scientific Precision Potentiometers: Single Turn, Multi-turn, Sine-cosine.

(Continued on page 350A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

THROUGH CONNECTRONICS®

GREMAR GUARANTEES 100% RELIABLE RF CONNECTORS

with absolute conformance to standard or special specs

One hundred and forty-two separate quality control checks assure the 100% reliability required by top military and civilian users of RF connectors.

Proof of Gremar's ability to meet the most stringent specifications: every major military project, from missiles to space capsules to atomic subs . . . specify Gremar. Every leading commercial manufacturer, from jet airliners to electronic instruments specify Gremar RF connectors.

Why . . . because Gremar Connectronics not only guarantees reliability and conformance to your specs, but *delivers on time,* too! By stocking America's most complete line of RF connectors and fittings . . . by maintaining a shelf stock of more than 500,000 assembled units, of over 2,000 types, and 4,000,000 component parts ready for assembly.

Gremar invites you to evaluate its superior RF stock connectors and its unique ability to engineer units to your special needs. Just fill out the coupon below for literature on all series . . . BN, BNC, TNC, C, SC, N, QDL, QDS, SM, HN, LC, LT, or PULSE, plus our 48 page comprehensive Cross-Reference Manual covering major RF connector manufacturers and users.

CUT OUT AND MAIL TODAY FOR FREE ENGINEERING DATA ON RF CONNECTORS!

Visit us at I.R.E. Booth 2217

FREE RF CONNECTOR DATA...

GREMAR

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MANUFACTURING CO., INC., WAKEFIELD, MASS.

Please rush your RF connector bulletins and Cross-Reference Manual to:

Name________________ Title________

Company________________________

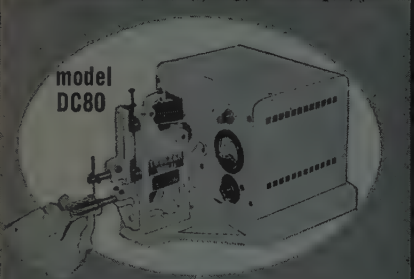
Address________________________

City______________ Zone____ State____

NOW produce up to 6,000 welds per hour . . . automatically . . . with one operator.

TWEEZER WELD

Precision Resistance Welding Equipment



BENCH MOUNTED STORED ENERGY WELDER

- New TW5 low friction welding head
- Stored energy panel of 80 Watt second capacity
- Discharge time of 0.0008 to 0.0012 second
- Permits welding of difficult materials, i.e.: copper, silver, tungsten, etc.
- Reliable welds without discoloration, deformation, metallurgical change

TWEEZER-WELD

COMPACT SYNCHRONOUS WELDING TIMER
6″ wide
10½″ high
8½″ deep
model T-3

TRANS-SYNC WELD-TIMER

- 1 KVA capacity utilizing semi-conductors
- Also ideally suited with high speed automatic machinery.
- Operates at a rate up to 1200 welds per minute . . . welds partially oxidized materials with ease.
- Welding time: ½ cycle (8 milliseconds) to 10 cycles (160 milliseconds).

FEDERAL TOOL ENGINEERING CO.
1400 Pompton Ave.
Cedar Grove, New Jersey

TWEEZER-WELD

WRITE FOR INFORMATION

Whom and What to See at the Radio Engineering Show

(Continued from page 349A)

Sanborn Co.
175 Wyman St.
Waltham 54, Mass.
Booths 3601-3605

Steven Bilowich, Ralph E. Hanson, ▲ R. Paul Foster, E. D. Pulsifer, Alfred E. Lonnberg, ▲ Dr. Arthur Miller, ▲ J. William Sauber, ▲ Morton H. Levin, ▲ Robert T. Danehy, Donald M. Brown

Model 320 Dual Channel Recorder

On display are these new DIRECT-WRITING recorders: rack-mounted 2-channel, portable 2-channel, rack-mounted 16-channel, optical 24-channel. New 8-channel 17-inch oscilloscope. Also on exhibit are: 350, 850, 950 Series equipment; Model 670A X-Y Recorder; pressure, displacement, velocity transducers.

Sanders Associates Inc.
95 Canal St.
Nashua, N.H.
Booth 1723

▲ Don Ayer, John Killelea, Harvey Hollister, Tom Dolan, Al Meyers, Lou Garten, Ken Glover, Morris Silverman

Modular components for microwave strip transmission including new crystal mount for MICRO-MIN diodes; Subminiature rate gyroscopes; FLEXPRINT flexible printed wiring for jumpers, cables, harnesses; miniature blowers.

Sanford Mfg. Corp., Booth 4038
See: Micromech Mfg. Corp.

Sangamo Electric Co., Booth 1921
11th and Converse Sts.
Springfield, Ill.

William S. Paine

Capacitive and Inductive Components, Mica, Paper, and Electrolytic Capacitors, Specialty Filters, Transformers, Pulse Networks and Toroidal Coils.

Sargent & Greenleaf, Inc., Booth M-22
See: Security Devices Laboratory

Saxton Products, Inc., Booth 4055
4320-26 Park Ave.
New York 57, N.Y.

Edward Abbo, Mark Kleiner, Jerome Firestone, Conrad Deutson

Wire & Cable Div. of Saxton Products maintains large stock CO-O Cable (Flexible & Extra Flexible 300 & 600 volts) MIL-C-3432A, CO-S types MIL-C-3884, also Teflon Types "E" and "EE" MIL-C-16878C. Specialists in Cable To Your Specification Including Short-Runs.

Schutter Microwave Corp., Booth 1726B
80 East Montauk Highway
Lindenhurst, N.Y.

▲ Norman Kjeldsen, ▲ Milton D. Hirsch, ▲ Edward Buckley, ▲ Dan McDonald, ▲ Frank Lippman

Microwave Components, Mixers, Duplexers, Bends, Attenuators, Adapters, Transitions, Suppressors and Rotary Joints & Dummy Loads.

Scientific-Atlanta, Inc.
2162 Piedmont Rd., N.E.
Atlanta 9, Ga.
Booth 3909

▲ Wm. H. Bradley, ▲ Glen P. Robinson, Jr., ▲ J. Searcy Hollis, ▲ Herbert W. Bass, Herbert Gentry, M. J. (Bud) McDonald, ▲ J. Emory Lane

Complete Antenna Test Ranges: Recorders, Positioners, Receivers, Model Towers, Remote Tuned Signal Sources, Fourier Integral Computers, Microwave Components, Standard Gain Horns, Pattern Integrators, Boresight Recording Systems, Special Test Systems.

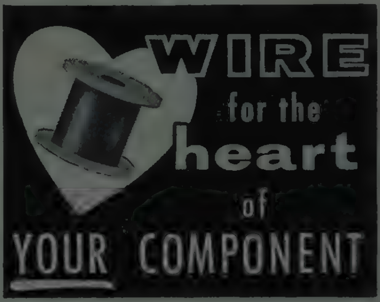
Sealectro Corp., Booth 2922
139 Hoyt St.
Mamaroneck, N. Y.

George E. Mohr, Milan E. Robich, Robert O. Walcovy, William Silberstein, Augustus S. True, Larry Willis, George Bechtold, Vincent E. Malkiewicz

Complete line of Teflon "Press-Fit" terminals—stand-off's, feed-thru's, jacks, and plugs. Complete new line of sub-miniature "ConheX" 50 and 75 ohm RF connectors—snap-on* and threaded engagement types. New automatic insertion machine*.

Secon Metals Corp.
7 Intervale St.
White Plains, N.Y.
Booth 4117

▲ Eugene Cohn, Richard Gordon



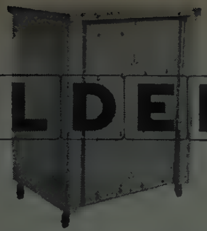
Wire for the heart of your component: engineered for precision potentiometers, semiconductors, resistance thermometers, and strain gauges. Fine ribbon, 1000°F. insulated wire, potting cements, galvanometer suspension strip, electroplated wire, high tensile strength magnet wire, fuse wire and Wooloston wire.

(Continued on page 352A)

▲ Indicates IRE member.

* Indicates new product.

The letter "M" preceding a booth number indicates that the exhibitor will be found on the mezzanine at the back of the first floor.

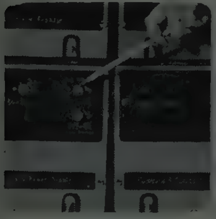


ALDEN

Plug-in components for electronic systems

Alden plug-in components offer far more than the convenience and ease of modular packaging . . . the prime advantage of these basic building blocks is that they make possible **more reliability in service.**

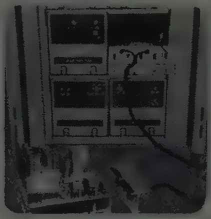
More in-service reliability through:



Tell-tale monitoring — all controls easily accessible, up front. Tiny tell-tales spot trouble instantly, isolate it to a specific modular unit.

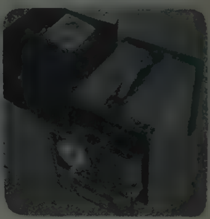
Quick removal — malfunctioning unit can be removed with a half turn of the wrist, reducing down-time to 30 seconds with plug-in spare.

Quick replacement — malfunctioning component can be snapped out and replaced in seconds.



In-service checks — Alden Adapter Cable brings chassis out into the open while in operation for quick checking.

Single point of check — all leads brought to single checkpoint — makes possible color coded, vividly illustrated circuit legends.

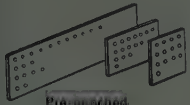


Quick repair — rugged, portable carrying case protects chassis. Replacement of malfunctioning chassis is only air mail time away from service center.

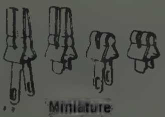
From layout to finished equipment...in just 3 steps:

1

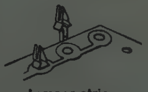
Unitize circuitry in compact, vertical planes with Alden Terminal Card Mounting System — Your circuitry is assembled in complete units, ready for housing.



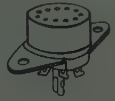
Pre-punched terminal cards



Miniature terminals



Jumper strip (eliminates wiring)

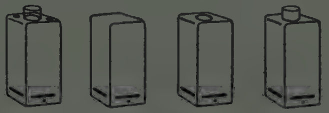


Card mounting sockets

Complete circuits ready for plug-in package or chassis

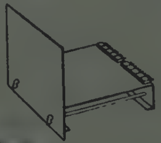
2

Mount cards in Alden Basic Chassis for tremendous variety with standard components — Alden provides standard plug-in or slide housings. With spares, units are replaceable in 30 seconds.



Alden plug-in package 4 sizes: 7, 9, 11, and 20 pin

Alden Basic Chassis



Picture Frame Rack Adaptor — for mounting Alden Basic Chassis in any combination. Mounts in standard rack or Alden UniRacks.

3

Mount sub-assemblies in Alden UniRacks — UniRacks fully utilize all the features of plug-in construction, give you a more compact, serviceable unit. Furnished in 2 basic heights, either mobile or stationary — easily accessible, front or rear.

Assign Alden testing and sensing elements to each unit to spot trouble instantly

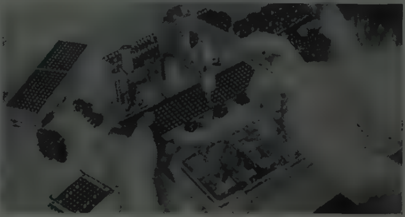
Miniature test jacks

Miniature indicator lights

Miniature Pan-i-lite Switch (momentary contact)

Stacking and patch cord

Two time saving, money saving, "GET STARTED" KITS



Terminal Card Mounting Kit #42 — Includes new Alden Staking Tool plus prepunched terminal cards, ratchet terminals, eyelets, brackets, and card mounting tube sockets—everything for simplified, time saving circuitry layout. **$49.95**

Basic Chassis and Terminal Card Assortment Kit #37 — All necessary components to mount, house, fasten and monitor your electronic circuitry. Makes sense, save time, establishes reliability. **$249.50**

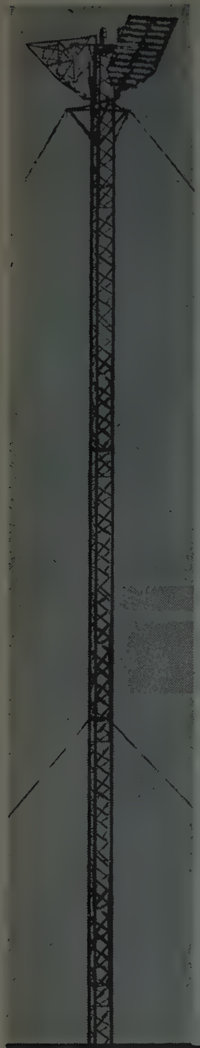
Other kits from $11.50

Write today for new Alden Plug-in Booklet and handy, up-dated Quick Order Guide.

ALDEN

PRODUCTS COMPANY, 3121 N. Main Street, Bockton, Mass.

See you at the IRE Show—Booths 1508, 1510



Towers
Reflectors
Buildings

- FIXED
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Complete installations for all communications purposes

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CONSTRUCTION CO.
2733 HAWKEYE DRIVE
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Tower Erectors and Fabricators the World Over!

MAIL TODAY! FOR 1959 CATALOG!
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2715 HAWKEYE DRIVE
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NAME:
ADDRESS:
CITY: ST:

Whom and What to See at the Radio Engineering Show

(Continued from page 352A)

Security Devices Laboratory
Electronic Div. Sargent &
Greenleaf, Inc.
24 Seneca Ave.
Rochester 21, N.Y.
Booth M-22
Joe Williams, Ron Fisher, Art Scalzo

reson-ator
MODEL J-500
FREQ. 977.2
SDL
reson-ator
MODEL J-610
FREQ. 977.2
SDL

Resonant Reed Relay; Oscillator Control

Reson-ator J610 Oscillator and J500 Relay Controls are extremely stable electro-mechanical component devices used to generate and decode specific alternating current signals. Also see our BF series Battery Holders to Accommodate all Batteries or Cells used in Subminiature Equipment.

Semiconductor Products, Booth 4215
See: Cowan Publishing Corp.

Be sure to
see all four floors!

Sensitive Research Instrument Corp.
310-316 Main St.
New Rochelle, N.Y.
Booths 3410-3412
Marvin I. Steinberg, Leonard J. Patterson, ▲ H. Russell Brownell, Louis Miller, Robert Most, F. Patrick Johnston, Mike Kane, Gerald D. Frank, Earl Elliott, Abe Isaacs

Laboratory Standardizing Test Console

Laboratory Standard Calibration Consoles, AC-DC to .05% accuracy; DC Voltage Standards ±.005% stability; Form-Factor meter; Radio Frequency Voltage Calibrator; Laboratory and reference standard portable and panel mounting electrical indicating instruments for measurement of voltage, current, power, frequency and magnetic quantities.

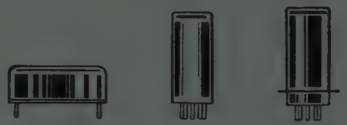
Servel Inc., Booth 2806
See: Burgess Battery Co.

(Continued on page 356A)

A NEW CONCEPT IN
MINIATURE CHOPPERS
by JAMES

A MINIATURE CHOPPER
WITH ALL MODELS OF
INSTRUMENT QUALITY!

- All with center pivot armatures
- All models for 100°C
- Low Mechanical noise
- Low residual noise

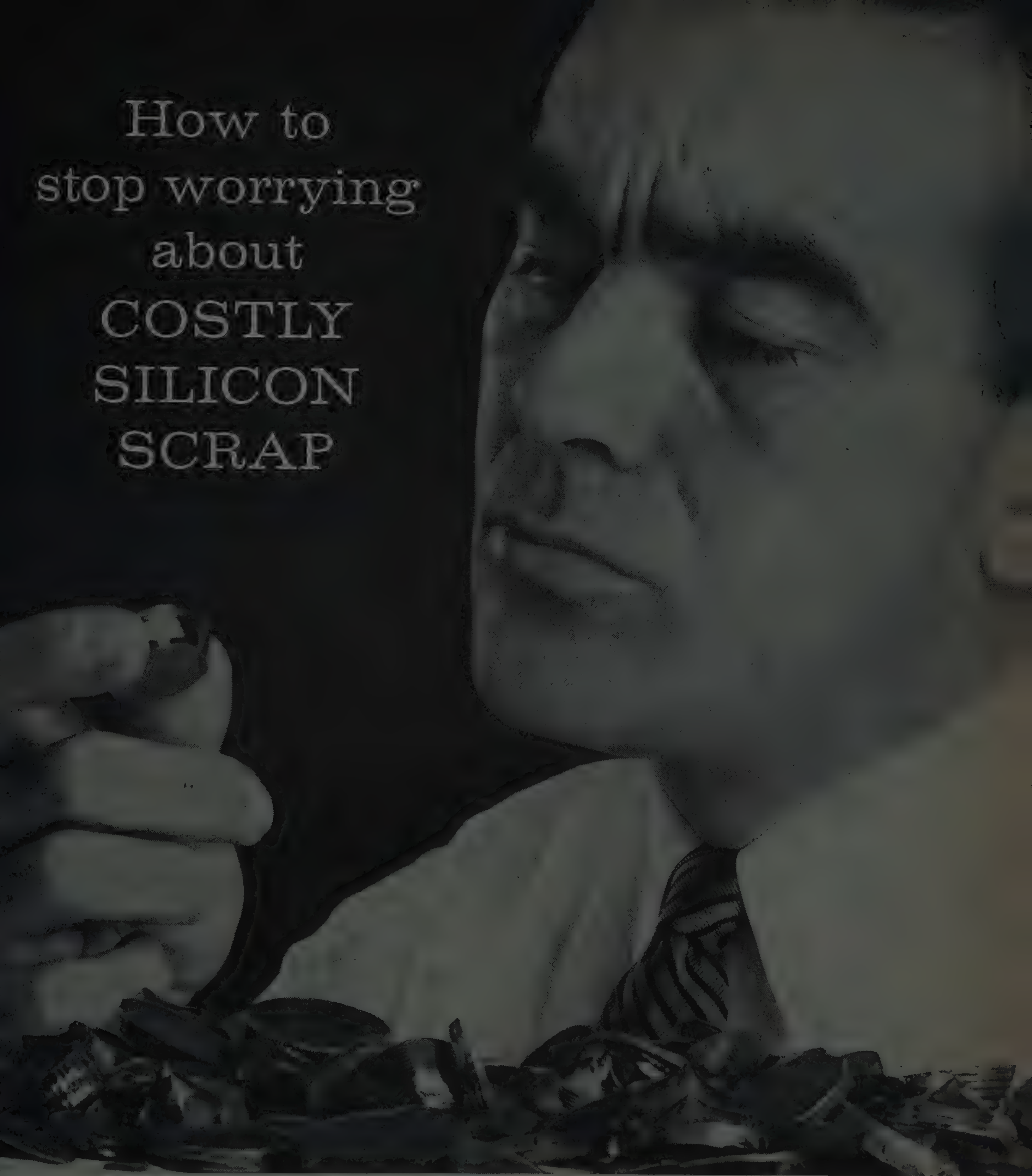


NEW Printed Circuit Board Mount
Standard 7 Pin Models
Flange Mounts

WRITE FOR CATALOG AND TECHNICAL DATA

DEPT. IRE-3

JAMES ELECTRONICS INC.
4050 N. Rockwell, Chicago 18, Illinois
CO 7-6333



Want to overcome the nagging problem of costly silicon scrap?

It's easy. Just specify Merck Single Crystal Silicon.

At one fell swoop you get rid of silicon rejects due to poor size control. Merck Single Crystal Silicon is of uniform diameter all the way down . . . good to the last millimeter. You won't get stuck with unusable butt-ends.

But that's not all. Float zone-refined Merck Single Crystal Silicon is uncompensated. Resistivities stay uniform day in, day out; month in, month out . . . whether you use p-type or n-type Merck Silicon. Your rejects due to unsatisfactory resistivities fall to zero.

Merck has the Single Crystal Silicon to meet your needs. Write, wire or phone today for specifications.

Visit our booth #4513 I.R.E. Convention

Electronic Chemicals Division

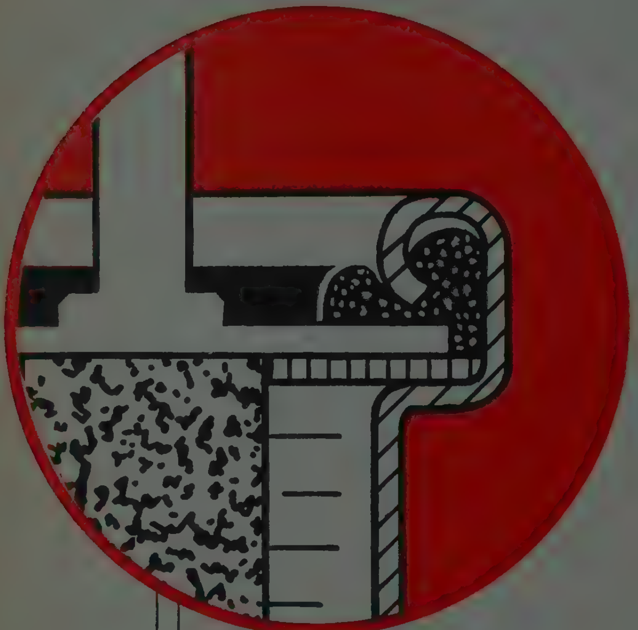
MERCK & CO., INC. • RAHWAY, NEW JERSEY

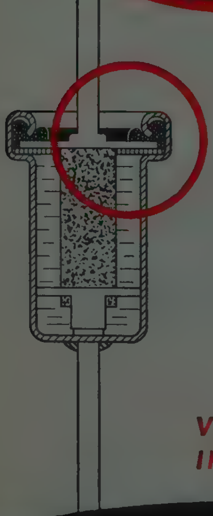
MERCK SILICON

BASE BORON CONTENT BELOW ONE ATOM OF BORON PER SIX BILLION SILICON ATOMS

Here's Why

The ORIGINAL Tantalum Capacitor Is Still The Best . . .





Over 10 years of laboratory testing and millions of applications in the field prove that Fansteel's patented shoulder and curl design provides *the best method of sealing* a tantalum electrolytic capacitor.

...because the shoulder and curl design of the silver case results in a spring action on the seal assembly at all times.

...because this downward pressure and tension remains constant throughout the capacitor's temperature range.

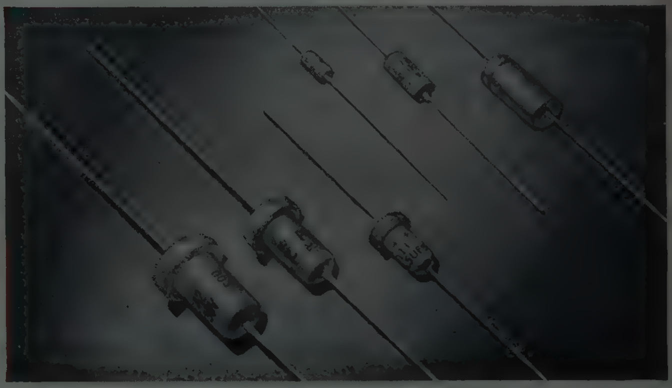
...because two gaskets—one above, one below the tantalum disk—create an air space, the only effective barrier against capillary action.

...because part of the upper gasket is formed into the curl for a perfect seal between case and gasket unaffected by varying temperatures.

...because all gasket materials are carefully selected and controlled in their parameters so as not to interfere with the curl's spring action.

...because there can be no loosening of the seal due to compression set.

Fansteel tantalum capacitors . . . electrolytic and solid types . . . complete ratings for all temperatures. Write for latest technical bulletins.



Visit Us At Booths 4021-4022 IRE Show

FANSTEEL

CE601

Fansteel Rectifiers

SELENIUM

. . . products of almost 30 years of Fansteel research and development in adapting selenium to rectifiers and perfecting cell designs that are now standards for industry.

Fansteel Selenium Rectifiers offer practically unlimited life with no maintenance. Instantaneous power with negligible leakage. Over 400,000 different stack combinations readily available in almost unlimited power ratings, any standard cell size or circuit.

Fansteel selenium cells are produced in dust-free, conditioned-air surroundings and undergo rigid testing for workmanship, performance and reliability.

Fansteel Rectifiers

SILICON

...d-c power sources for all applications requiring highest reliability under severe service conditions. Produced under exacting "white room" conditions using finest-quality materials. Thorough, 100% testing assures peak performance.

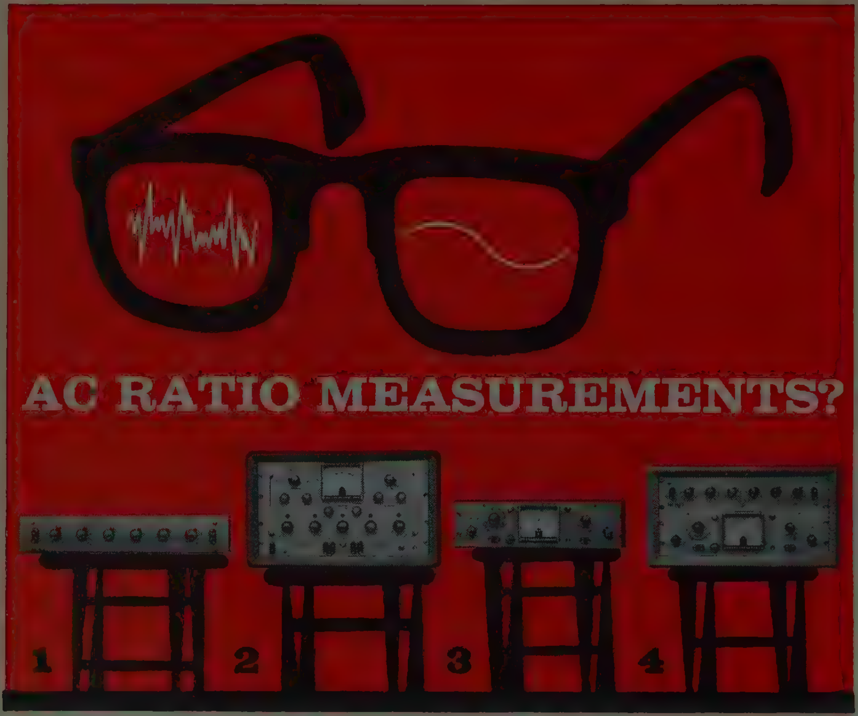
22 amp., 35 amp. and 75 amp. types, 1N Series, individual or in stack assemblies with bridge, center tap or doubler circuits.

Write for Bulletins

FANSTEEL METALLURGICAL CORPORATION
North Chicago, Ill., U.S.A.

FANSTEEL

RELIABILITY



THERE'S A NORTH ATLANTIC INSTRUMENT TO MEET YOUR REQUIREMENTS, TOO...

Now—from North Atlantic—you get the complete answer to AC ratio instrumentation problems—in the laboratory, on the production line, in the field.

Specialists in ratiometry, North Atlantic offers the only complete line of precision instruments to handle any ratio measurement task. All are designed to meet the most demanding requirements of missile age electronics—provide high accuracy, flexibility, component compatability and service-proven perforformance. Some are shown above.

If your project demands total solution to ratio measurement problems, write for Date File No. 10K. It provides complete specifications and application data and shows how North Atlantic's unparalleled experience in ratiometry can help you.

1. RATIO BOXES:	2. COMPLEX VOLTAGE RATIOMETERS	3. PHASE ANGLE VOLTMETERS	4. RATIO TEST SETS
Both laboratory standards and general duty models. Ratio accuracies to 0.0001%. Operation from 25 cps to 10 kc.	Integrated, single-unit system for applications where phase relations are critical. Accuracy to 0.0001%, unaffected by quadrature. Three frequency operation. Direct reading of phase shift in milliradians or degrees.	Versatile readout system for all ratiometry applications, providing direct reading of phase, null, quadrature, in-phase and total voltage. Broadband, single-, or multiple-frequency operation.	Ratio reference and readout in one convenient package for production line and similar applications. Can be supplied with any desired combination of ratio box and phase angle voltmeter.

NORTH ATLANTIC INDUSTRIES, INC.
603 MAIN STREET, WESTBURY, N.Y. • EDGEWOOD 4-1122
See us at IRE—Booth 3833

Whom and What to See at the Radio Engineering Show

(Continued from page 352A)

Servo Corporation of America, Booths 3806-3808
111 New South Road
Hicksville, L. I., N. Y.

Walter Campbell, Arthur Freed

Electronic Equipment, Pyrometer, Servo System Test and Analysis Equipment and Systems. Model Servotherm®, Servoscope®.

See also: Electro-Pulse, Inc., Booths 3810-3812

Servo Dynamics Corp., Booths 1401-1407
Subsid. National Co., Inc.
Somersworth, New Hampshire

R. H. Rogers

Servo motors, damping generators, tachometers, gear heads, inertia damping servo motors, servo subsystems.

Servomechanisms, Inc., Mechatrol Division, Booth 2812
1200 Prospect Ave.
Westbury, L. I., N. Y.

Victor See, E. J. Chevins, L. R. Pensiero, R. N. Sebris, N. A. Christian, G. L. Dinger, D. Ladner

Servo Motors, Hysteresis Synchronous Motors, Integral Gearhead Motors, Viscous and Inertially Damped Servo Motors, Damping and Temperature Compensated Integrating Tachometers, Stepper Motors, Clutches, Electronic and Mechanical Breadboard Parts Including Amplifiers, Power Supplies, Modulators (60 and 400 cycles), Counters and Potentiometers.

Shallcross Mfg. Co., Booth 2634
Selma, N. C.

John S. Shallcross, Don M. O'Halloran, Dewees H. Shallcross, Jr., R. I. S. Crisp, R. A. Avery, Robert W. Mills, Clayton Huber

Precision Resistors, Rotary Switches, Instruments, Delay Lines, Resistor Networks, Audio Attenuators, Coils.

Shepherd Industries, Inc.
103 Park Ave.
Nutley 10, N.J.
Booth 2937

John French, Dan Giffin, ▲ Dr. William Duerig, ▲ William Murphy, Art Leuthesser, ▲ Don Killen, L. L. Driggs, Dan Coll, Dave Carpenter

Digital Tape Transports, *Bin Type and *Airborne; *Digital Magnetic Memory Drums; *Magnetic Heads for Tape Transports and Drums; *Logic Circuitry, *Solid State Amplifiers; *Analog Tape Transports.

Shielding, Inc.
514 North Read Ave., P.O. Box 3
Riverton, N.J.
Booths 3061-3062

▲ J. W. McDonald, Jr., ▲ T. P. Reath, J. J. Mooney, J. J. McDevitt, W. J. Ryan, D. J. Shamp

Typical Solid Enclosure

'Universal' RF shielded enclosures. Dust-free rooms, Environmental Test Chambers, Modular panel all purpose room, Microwave Absorbtion Enclosures, Pedestal Flooring Systems.

Whom and What to See at the Radio Engineering Show

Shockley Transistor Corp.
Sub. Beckman Instruments, Inc.
Stanford Industrial Park
Palo Alto, Calif.
Booth 1205

H. S. Schuler

Four-layer silicon diodes (for switching). Compensated Avalanche Diodes (for voltage regulation).

Shurite Meters, Booth 2833
See: J-B-T Instruments, Inc.

Sibley Company, Booth 1100B
Bridge St.
Haddam, Conn.

W. F. Moore, D. Dewey, M. Whiston, B. Roffman, R. Murray, W. Murray, J. Churchill, R. S. Pettigrew, H. Carvey

Printed circuits, flush commutators, drum commutators, plated-through hole circuits. Precious metal plating of electronic parts. Electronic assemblies. Engineering research and development, department for circuitry conversion, miniaturization and high temperature applications.

F. W. Sickles Co., Booths 1218-1224
See: General Instrument Corp.

Siegler Corp., Booths 1427A-1427B & 3214
See: Magnetic Amplifiers, Inc. & Bogen-Presto Co.

Sierra Electronic Corporation, Subsid. Philco Corporation, Booths 3031-3032
3885 Bohannon Drive
Menlo Park, Calif.

C. M. Volkland, H. D. Farnsworth, M. J. Gothberg, S. K. Ashby, ▲ W. Feldscher, ▲ S. Frankel, ▲ G. K. Patterson

*Frequency Selective Voltmeters, *Calorimeter Systems, *Harmonic Filters, *FM Signal Generator (SL band), Line Fault Analyzers, Oscilloscopes, Transistor Tester, Power Sources, Power Monitors, Termination Wattmeters, Directional Couplers, Stub Tuners, Coaxial loads, Waveguide Loads, Ion Gauges.

Sierra Research Corporation, Booth 3015
P.O. Box 22
Buffalo 25, N. Y.

John P. Chisholm, Harold K. Fletcher, ▲ Herbert Mennen, ▲ Vernon H. Siegel, Robert J. Theisen, ▲ Sherwood H. Calhoun

Product History: Research, development, and fabrication of data transmission equipment: *PAM Coders and Decoders; computer accessories: *Analog Multipliers; radar equipment: *Broadside Array Antennas, *Transistorized Indicators, *Target Simulators; and ship motion recording instrumentation: *High-level Torque Meters.

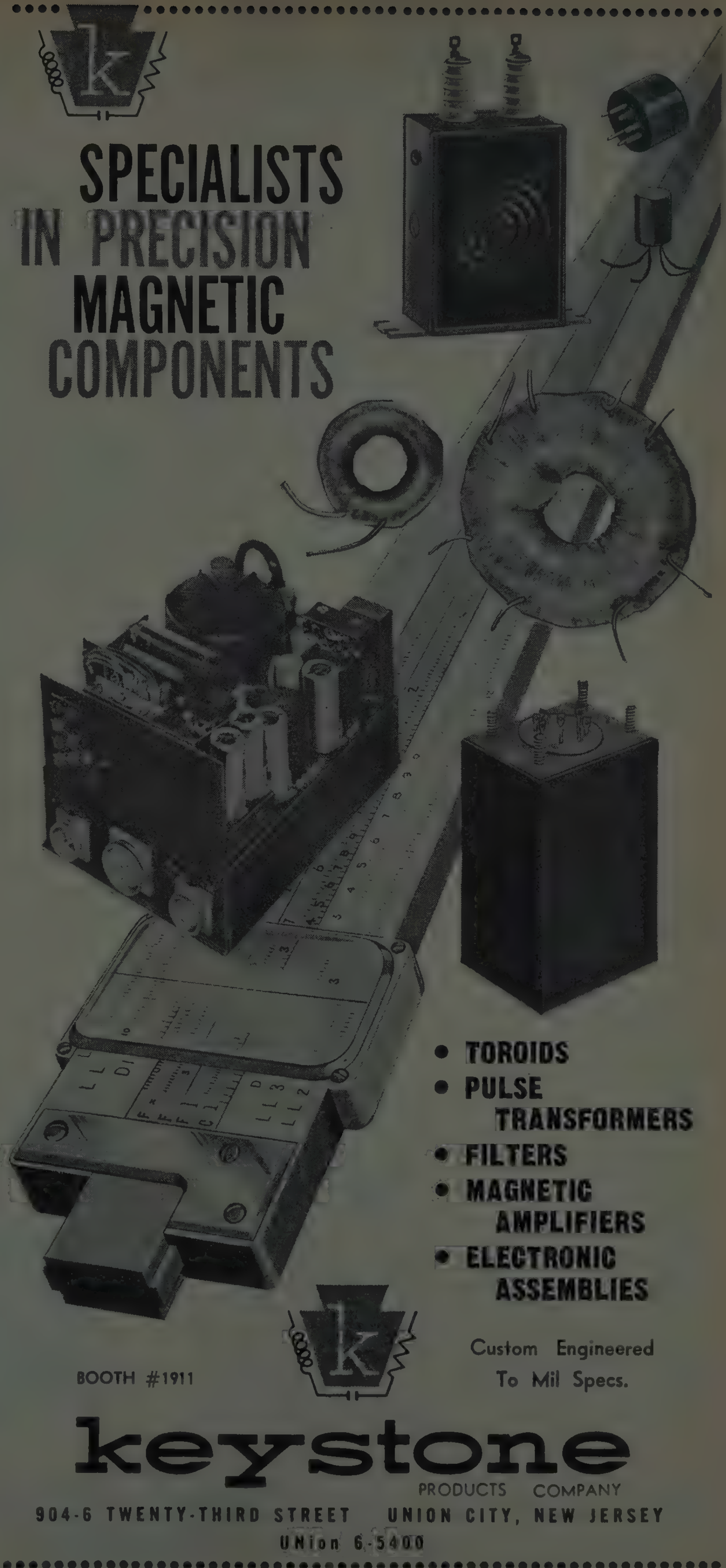
(Continued on page 360A)

▲ Indicates IRE member.
* Indicates new product.

See all the exhibits!

Don't miss these important locations—

Mezzanine at back of first floor, South Room at center of south wall, second floor. 3000 court at southeast corner of third floor, 4000 court at southeast corner of fourth floor, 4500 court in northwest corner of fourth floor.


SPECIALISTS IN PRECISION MAGNETIC COMPONENTS

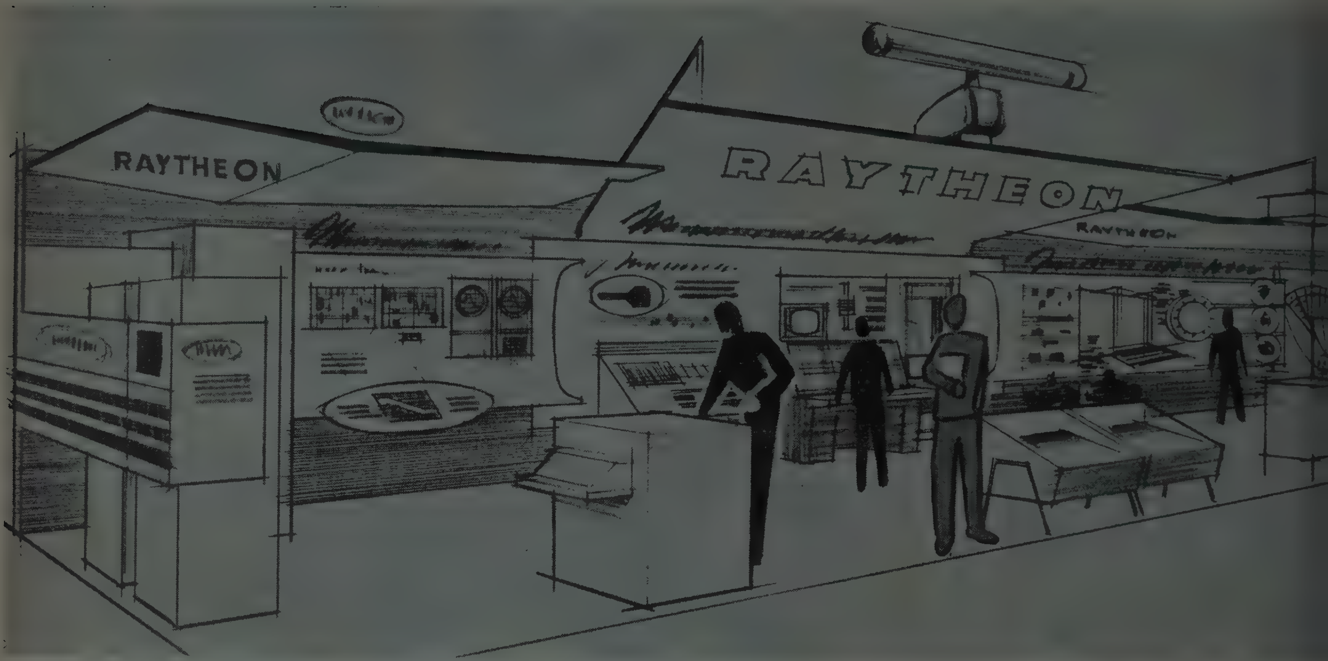
- TOROIDS
- PULSE TRANSFORMERS
- FILTERS
- MAGNETIC AMPLIFIERS
- ELECTRONIC ASSEMBLIES

Custom Engineered To Mil Specs.

BOOTH #1911

keystone
PRODUCTS COMPANY
904-6 TWENTY-THIRD STREET UNION CITY, NEW JERSEY
UNion 6-5400

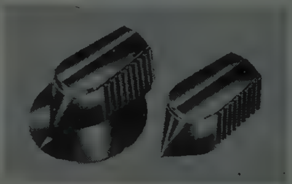
See these new Raytheon Product



INDUSTRIAL COMPONENTS DIVISION

New Kilo-line recording storage tubes provide 1000 TV lines at 50% modulation. These high-resolution, low-noise tubes for frequency and scan conversion utilize a specially designed tetrode electron gun for a resolution of 1,000 TV lines at 50% modulation and provide better control over beam cut-off than conventional triode guns. Applications include: (1) scan conversion for bright display radar and moving target indicators, (2) slow-down video for still picture telephone transmission, (3) stop-motion video.

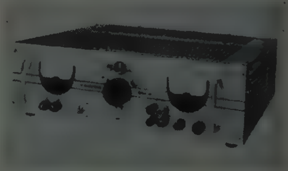
New pointer knobs virtually eliminate parallax. Two new sloping pointer style control knobs have been added to Raytheon's widely used commercial and military knob line. The new pointer series complies fully with military specifications and is available in black or grey, with or without dial skirts; in mirror or non-reflective matte finish. Colors are available on special order. Raytheon's complete line of knobs includes 206 styles —9 standard types in 6 sizes, plus tactile shapes, color and color caps.



COMMERCIAL APPARATUS & SYSTEMS DIVISION

New Voltage-regulating PF transformer holds voltages to within ± 3%. The new Raytheon voltage regulating PF transformer maintains plate and filament voltages to within ± 3% of rated output with line voltage variation of from 100 to 130 volts. PF transformers are now available in three standard models with ratings up to 380 VDC at 250 MA. They eliminate need for VR tubes and special circuitry.

Sorensen Series Q line of power supplies for 6, 12 or 28 VDC regulated. The Sorensen Series Q power supply line is comprised of 15 different models with outputs of 6, 12 or 28 VDC, adjustable approximately ± 25%. Voltages are regulated within ± 0.05% for load and line combined. Power capacities range up to 200 watts. The complete line of Sorensen power supplies covers requirements from 600,000 volts down to 3 volts. Sorensen also offers a line of frequency changers and line voltage regulators.



Visit us at the New York Coliseum, Booths 2604-2614

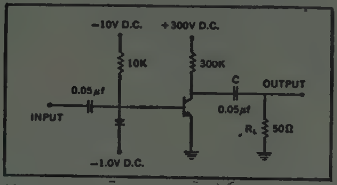
Developments at the IRE Show

ON THE SECOND FLOOR, to the right of the escalator, you'll find this Raytheon exhibit of electronic component and equipment advances—N. Y. Coliseum, Booths 2604-2614.

SEMICONDUCTOR DIVISION

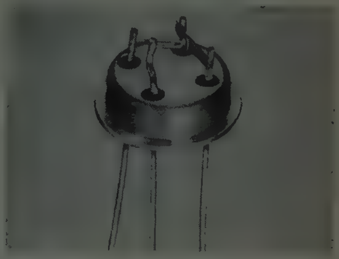
New "Avalanche Mode" Silicon Transistor switches in 2½ milli-μsec.

A guaranteed switching time of 10 millimicroseconds maximum (when used in the switching circuit shown) with speeds faster than 1½ millimicroseconds in some applications is now possible with Raytheon's new 2N1468 Silicon NPN transistor for avalanche mode operations. Other features: 40 watts peak power, average power dissipation of 250 milliwatts, maximum operating temperature of 125°C.



New Silicon Mesa Transistor in Subminiature Package.

Raytheon's Semiconductor Division announces the availability of high-performance Silicon Mesa transistors in subminiature packages (.130" D., .160" H.). These units feature the reliable "Mesa" construction, alpha cut-off frequencies up to 50 megacycles and close control of DC base-current gain in high-speed switching types.



MICROWAVE AND POWER TUBE DIVISION

Four new ruggedized backward wave oscillators cover 1-12.4 kmc.

Four compatible Raytheon BWO's now provide continuous frequency coverage from 1 to 12.4 kmc. They utilize interdigital delay-line structures for greater ruggedness and heat dissipating characteristics, are smaller and lighter than their predecessors and have improved fine-grain tuning variations with minimized fine-grain power output variations. Forced air cooling is not required under normal operating conditions.

New ferrite circulators for masers, parametric amplifiers and radio astronomy.

A standard line of extremely compact, low-frequency, three-port ferrite circulators is now available from Raytheon. Now, a total of twenty-eight units are available—for UHF as well as S- and L-band applications. The new UHF unit extends the frequency range down to 400 mc. These circulators are supplied with fixed permanent magnet fields (as illustrated) or with tuned magnetic fields for full performance over a broader band.

MACHLETT LABORATORIES

UHF planar triode has 60% more cathode current capacity.

This unique, Machlett developed UHF planar triode with ceramic envelope has 1.6 times the cathode current rating of the more conventional tubes in current use. The new ML-7211 has applications in communications, navigation, telemetering, radar and missile equipment of the most advanced design.

Improved camera tube for general closed-circuit TV applications.

Machlett's novel vidicon camera tube features photoconductor guard and self-aligning beam eliminating the need for permanent magnets or coils. This tube will be exhibited at the IRE along with Machlett's water-cooled triode rated at 20-megawatts peak power, a scan conversion tube for conversion of radar information to TV display, and a high-power vapor cooled tube for general purpose modulator, amplifier and oscillator services.

RAYTHEON COMPANY
Waltham, Massachusetts

RAYTHEON

Excellence in Electronics

Whom and What to See at the Radio Engineering Show

(*Continued from page 357A*)

Sigma Instruments, Inc.
170 Pearl St.
S. Braintree 85, Mass.
Booths 2733-2735

P. Garnick, R. B. Wolf, C. E. Heller, H. W. Fleming, W. H. Holcombe, F. C. Burridge, R. H. Pierce, L. D. LaFlamme, L. B. Stein, Jr.

Sigma Series 9C "Cycloswitch"

Stepping motor—operates up to 400 steps/sec.; with printed circuit becomes 10 and/or 20-position stepping switch*, speeds up to 240 steps/sec. Microwatt-sensitive magnetic amplifier*—for precise detection and control of temperature. Relays—sensitive, for general purpose and special applications.

Signal Magazine
1624 Eye St., N.W.
Washington 6, D.C.
Booth 4226A

W. J. Baird, Judith H. Shreve, Rita A. Gallagher

SIGNAL

SIGNAL Magazine—Official monthly publication of the Armed Forces Communications & Electronics Association, serving all branches of Government and Industry as it endeavors to maintain and improve the cooperation between the Defense and Industry Team in the design, maintenance and operation of communications, electronic and photographic equipment.

Silicon Transistor Corp., Booth 1105
150 Glen Cove Road
Carle Place, L. I., N. Y.

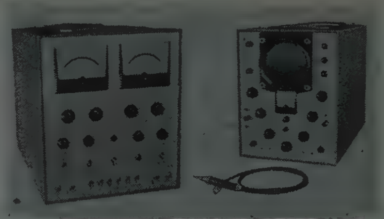
Robert L. Ashley, Randolph Bronson, ▲ Gerard Chesnes, Donald Des Jardin, ▲ Shao Chang Feng, Laurence LeBow, Vincent Lodestro, ▲ Harold Sandler, John Clarke

Reliable silicon high conductance, fast switching, high temperature circuit diodes in subminiature glass package. Reliable silicon transistors, 30 watt, 5 amps, low saturation resistance. Also *silicon zener sub-miniature diodes and *low capacitance fast switching silicon diodes.

Simberkoff Sales Co., Booth 1117
See: Collins Electronics Mfg. Corp.

Simpson Electric Company
5200 W. Kinzie St.
Chicago 44, Ill.
Booths 2221-2225

Jack Whiteside, Mel Buehring, Pete De Paolo, Bill Johansen, Al Arbeiter, Irv Rebeschini, Art Stephens, Bill Coon, Frank Hadrick, Vito Racanelli, Ed Evenson

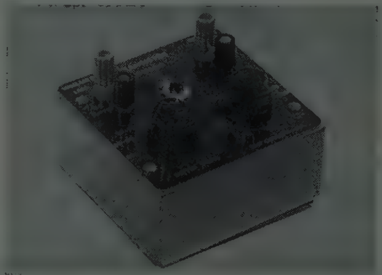


Laboratory Test Equipment

Laboratory Test Equipment featuring wide band oscilloscope, pulse generator, and self powered laboratory standard calibrator. Complete line of meters in various styles & sizes designed for stock & custom. Round, rectangular, & wide vue. Portable test equipment for Industrial, Radio/TV, Military & Communications applications.

Sinclair Radio Laboratories Ltd.
21 Toro Road, Box 179,
Downsview P.O.
Toronto 15, Canada
Booth 1630

▲ P. Yachimec, ▲ W. V. Tilston, ▲ A. H. Secord, ▲ F. G. Buckles, ▲ J. V. Hanson, ▲ J. R. Richardson, R. G. Sears



*New Transistor Guard, Model 101

Communications Antennas, Filters, Duplexers, Band-Pass Cavities, Antenna Decouplers, Repeater Duplexers, Common Antenna Multicouplers, Antenna Test Set, Transistor Guard—Solid State Circuit Breaker.

Singer Manufacturing Co.
Military Products Division
149 Broadway
New York 6, N.Y.
Booths 1819-1823

David Ernest, Richard Norwood, Edward F. Hall, Joseph C. Ike, ▲ W. B. Hunter, ▲ J. R. Schochet, ▲ F. W. Howells, ▲ T. W. Benedict, ▲ L. D. Rexroat, P. H. Kirwin, F. C. Helies

MILITARY PRODUCTS DIVISION

Swami Motion Detector, "Repli-Kote" systems, "Hi-Shock" rotary solenoid actuated switching mechanisms, servo-mechanism components in modular design, amplifiers, radar simulator, infra-red reconnaissance camera with data-link, computer with audio playback, radar signal simulator. Diehl Mfg. Co.: Instrument servo amplifiers for driving 1, 5 and 10 watt motors, precision resolvers, phase shifters up to 3.5 mc, complete line ac servomotors from 1 watt through 3 HP in 60 & 400 cps with integral ac or dc tachometers.

Skottie Electronics, Inc., Booth 2602
See: Astron Corp.

Skydyne, Inc.
River Rd.
Port Jervis, N.Y.
Booths 4515-4515A

▲ R. L. Weill, W. F. MacCallum, R. D. Cooper, G. B. Parsons, Steven E. Mautner, Lawrence A. McFadden, Victor Orben, W. M. Clevenstine, E. M. Porter

Sandwich Material Test Benches and Transit Cases, featuring a completely new design and construction concept for greater protection of sensitive equipment—one piece construction—completely bonded—also Fiberglas Cases for Instruments and Equipment—Combined Transportation & Operational Cases.

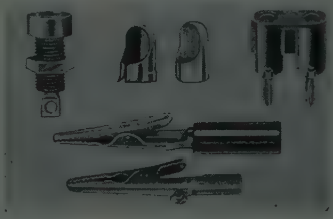
Slip Ring Company of America
3612 W. Jefferson Blvd.
Los Angeles 16, Calif.
Booth M-5

Robert A. Felburg, Robert E. Wolfe, Charles Gehrke, Don A. Hausrath

Stable Platform Slip Rings & Stable Platform Simulator For Testing. Noble Metal Slip Ring and Switching Devices.

Herman H. Smith, Inc.
2326 Nostrand Ave.
Brooklyn 10, N.Y.
Booth 2325

Ira L. Landis, Sheldon Sackman, Charles Gold, Nat Kopf, Harry Weston



New Products of Herman H. Smith, Inc.

Phone Tip and Banana Plugs, Jacks, Binding Posts, Alligator Clips, Test Leads, Patch Cords, Phone Plugs and Jacks, Panel Indicators, Knobs, Turret Terminals, Shaft Accessories, Terminal Lugs, Strips, Boards, Hi-Fi Cords, Sockets, Hardware, Switches. New (illustrated): Dual Banana Plugs, Jumbo Clips, Pilot Light Shields, Nylon Banana Jacks.

Sodeco—Geneva, Switzerland, Booth 3012
See: Landis & Gyr, Inc.

(*Continued on page 364A*)

First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

▲ Indicates IRE member.
* Indicates new product.

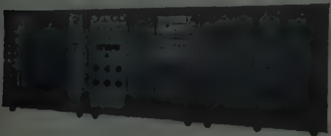
packaged by LEVINTHAL

These examples cover four ranges of Levinthal klystron power amplifiers. All of them are of top commercial quality and all are suited to the requirements of power-increase problems in existing systems. They can be supplied for c-w or, with various types of modulators, for pulse operation. Further, any of them can be supplied with a signal-source driver to operate as a complete transmitter.

One of these may be the solution for one of your current problems. If not, tell us what your needs are and let us supply information on other examples of our equipment engineering.

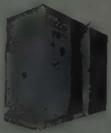
50 KW—MODEL 241T

This equipment, illustrated above, is typically capable of 50-kw c-w output with 45-db gain in the 300 to 500-mc range, using an Eimac 4KM170,000LA klystron. Pulse capability up to 200 kw can be provided.



10 KW—MODEL 82T

Considering tubes readily available, this Levinthal transmitter can be supplied with typical gains ranging from 25 to 40 db in frequency bands ranging from 225 to 2400 mc.



2 KW—MODEL 208T

Here, a series of typical klystrons gives a selection of operations with gains from 30 to 50 db over frequency bands including extremes of 385 and 8500 mc.

1 KW—MODEL 74T

A variety of klystrons is available to provide the Model 74T with typical gains from 25 to 60 db and frequency bands ranging from 385 mc to 10.8 kmc.

This year Levinthal will be exhibiting jointly with Radiation Incorporated, the parent company, at the New York IRE International Convention. Drop in to see us at booths 3003 and 3004.

Levinthal specializes in the production of high-power r-f transmitters and modulators for c-w or pulsed application. There are presently numerous attractive openings in the expanding engineering force at Palo Alto. If you are thinking about a new direction in your career, send us your resume and let us tell you something about the general advantages of working on the San Francisco Peninsula and those applying to Levinthal in particular.

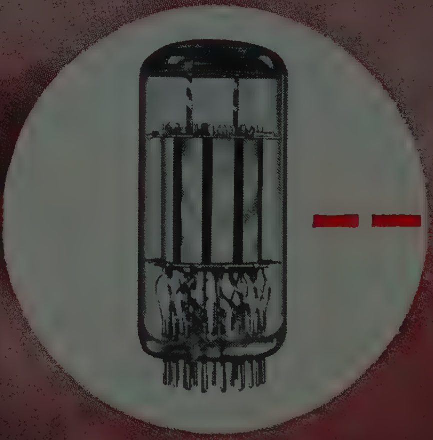
LEVINTHAL ELECTRONIC PRODUCTS

STANFORD INDUSTRIAL PARK, PALO ALTO 4, CALIFORNIA

SUBSIDIARY OF
RADIATION
INCORPORATED

New "Beam-X"* switc

outperforms al



solid state, vacuum & magnetic devices

IN MULTIPOSITION SWITCHING, COUNTING AND DISTRIBUTING

THE

BEAM-X*

IS AN

ALL-ELECTRONIC

MULTIPOSITION

SWITCH

The *BEAM-Xeliminates**

Multicomponent size

Multicomponent weight

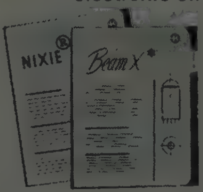
Multicomponent power

Multicomponent cost

and

Multicomponent unreliability

A technological breakthrough in the design of Beam Switching Tubes eliminating external magnets and shields has resulted in a low cost revolutionary device. *BEAM-X** outperforms all existing solid state, magnetic and vacuum components for electronic switching applications. In aircraft, missile, commercial instrumentation, control systems and other industrial applications, *BEAM-X ** offers far superior design flexibility and reliability than existing conventional components. *BEAM-X** type BX-1000 is the first of a new family of multiposition electronic switches.



WRITE TODAY FOR TECHNICAL BROCHURE DESCRIBING THE OPERATION AND COMPLETE MECHANICAL AND ELECTRICAL APPLICATION DATA OF THIS NEW BURROUGHS *BEAM-X** SWITCH.

SEE US AT
IRE SHOW BOOTHS
1211-1213-1215

ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

ELECTRONIC TUBE DIVISION
Plainfield, New Jersey

EAM-X*APPLICATIONS:
COUNTING • CODING • DISTRIBUTING • CONVERTING • GATING • MULTIPLEXING • SWITCHING
TIMING • SAMPLING • MEMORY • MATRIXING • PRESETTING • DECODING • DIVIDING

TRADEMARK OF BURROUGHS CORPORATION

Whom and What to See at the Radio Engineering Show

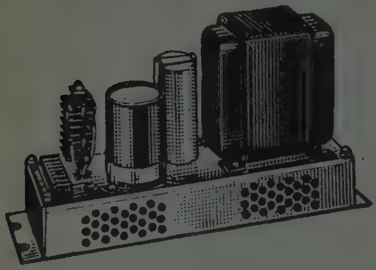
(Continued from page 360A)

Sola Electric Co.

Div. of Basic Products Corp.
4633 West 16th St.
Chicago 50, Ill.

Booths 2815-2819

▲ H. U. Hjermstad, ▲ R. H. Schlote, ▲ J. P. Kennedy, ▲ J. T. Keefe, ▲ R. Du Chatellier, J. E. Warhola, L. C. Marschall, N. P. Marshall, H. H. Maass, Don Frandson, R. J. Hesse, James Bowen



Fixed Constant Voltage DC Power Supply

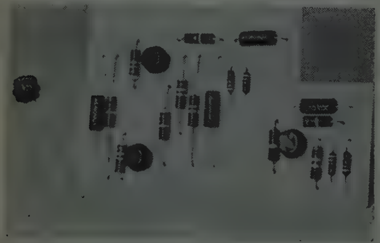
Sinusoidal output, constant voltage transformers from 60 VA to 15 KVA; regulated plate and filament transformers; regulated dc power supplies; industrial battery chargers; xenon-arc lamp, automatic-starting, power supplies, constant voltage and conventional transformers from 15 VA to 15 KVA.

Solid State Products, Inc.

1 Pingree St.
Salem, Mass.

Booth 1519B

▲ Robert W. Diamond, ▲ James B. Hangstefer, ▲ Lloyd H. Dixon



Silicon PNPN Controlled Switches and Miniature Controlled Rectifiers for high speed medium power switching. PNPN Trigistors for logic circuitry feature pulsed on-off control at base input. Diffused Silicon Transistors.

Sonobond Corp., Booth 4238

See: Aeroprojects, Inc.

Sonotone Corporation

Electronics Application Div. & Battery Div.
Elmsford, N.Y.

Booth 1901

E. F. Murphy, D. A. Hammelmann, R. J. McCarthy, R. Mainzer, R. A. MacEachern, P. A. Caddoo, R. L. Lewis, R. Mahler, C. Condike, W. Tietsworth, C. D. Grossman, L. Z. Sajor

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Sintered-Plate, Nickel-Cadmium Batteries for missiles, aircraft, communication equipment, etc. Portable Battery Packs and Rechargeable Flashlight Battery Cartridges. Charger-Analyzers. Stereo Phonograph Cartridges, Tape Heads, Microphones and Loudspeakers for high fidelity equipment. Electronic Tubes. Miniaturized Circuits.

Sony Corporation

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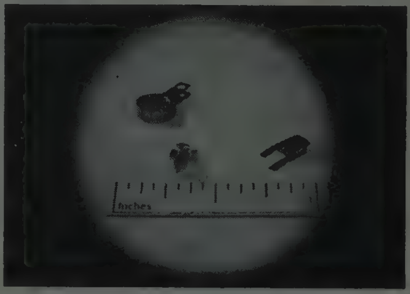
New York 12, N.Y.

Booth 2004

▲ Kazuo Iwama, Dr. Saburo Uemura, Keiichi Nakamura



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Transistors, Diodes, *ESAKI "Tunnel Diodes," Other Semiconductor Products.

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Booths 2604-2606

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▲ Norman Schwartz, Geo. E. Gansell, Bill Gold, Charles G. Hampson, Jack Klein, Charles Binder

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See: Diamonite Products Mfg. Co.

Spaulding Fibre Co. Inc., Booths 4505-4507

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W. R. Gilsdorf, E. C. Leitz, J. E. Miner

Spauldite laminated thermosetting plastics including phenolics, melamines, epoxies, and copper clad materials. Also vulcanized fibre, fibre boards and fabricated parts.

(Continued on page 368A)

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IRE MEMBERSHIP. The IRE membership booths at the Waldorf-Astoria Hotel and the Coliseum main lobby can provide you with information and application blanks for IRE membership and professional group membership. Also available here are membership cards and pins, IRE publications, and order blanks for the "Convention Record" which gives the complete text of all papers presented at the convention.

CAFETERIA. Second mezzanine at south side of floor. Take elevator 16.

FIRST AID ROOM. First mezzanine at north side of floor. Take elevator 20.

LIST OF REGISTRANTS. A complete list of all persons who have registered, brought up to date twice daily, is on the first mezzanine at the back of the first floor.

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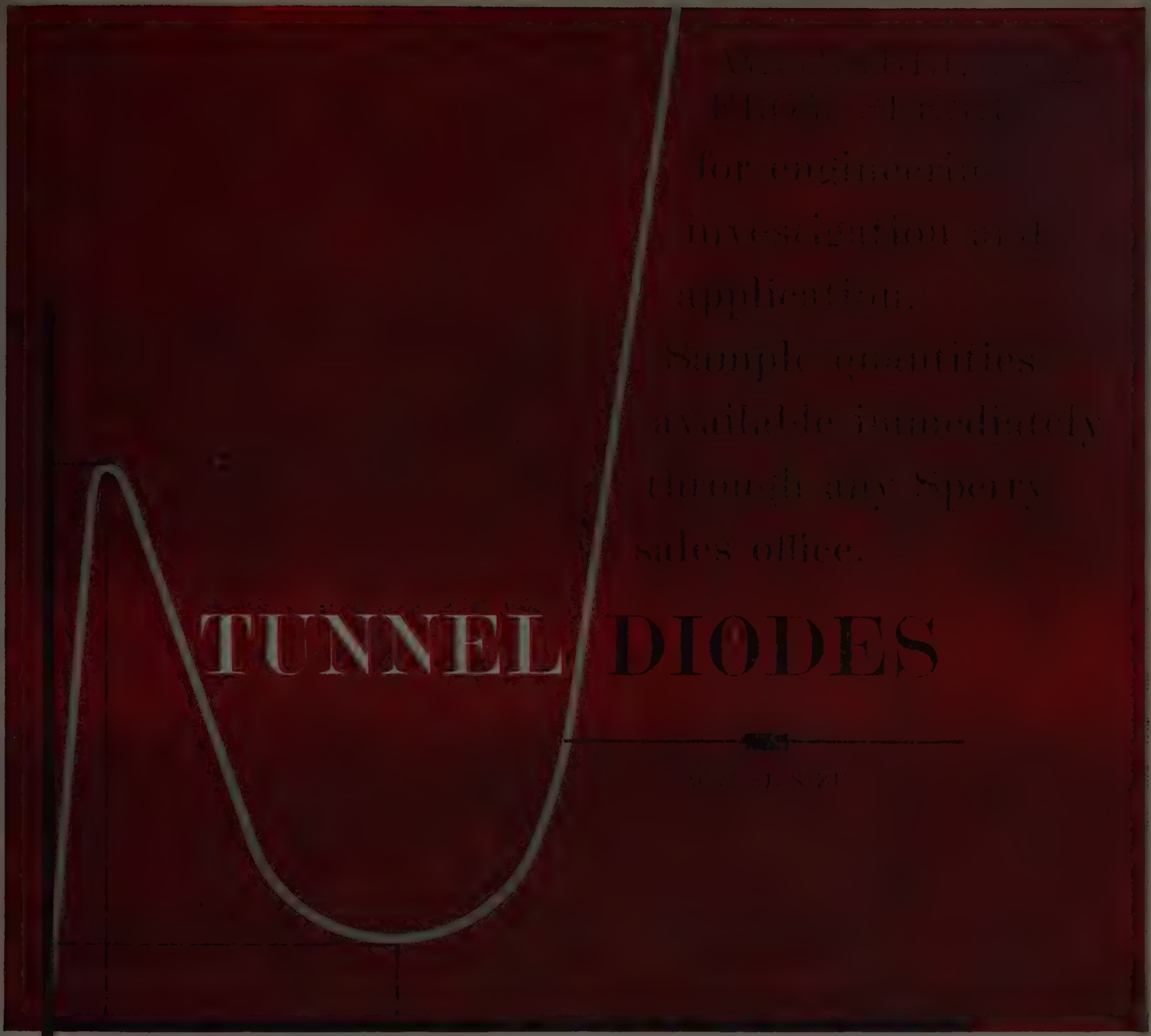
* Indicates new product.



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ACTUAL SIZE

TENTATIVE SPECIFICATIONS

Type	(TYPICAL VALUES)				T
	I_{peak}(ma)	I_p/I_v(min)	V_{peak}(mv)	V_{valley}(mv)	
T101	0.8	4.5	55	300	−55 to 100°C.
T102	1.5	4.5	55	300	−55 to 100°C.
T103	3.5	4.5	55	300	−55 to 100°C.
T104	7.0	4.5	55	300	−55 to 100°C.

SPECIAL SAMPLE OFFER

Order 5 tunnel diodes (T101 or T102) for $150, or request price on other types from the nearest Sperry sales office listed below.

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Call or write: *Sperry Semiconductor, Wilson Avenue, SOUTH NORWALK, Conn., VOlunteer 6-1641; In NEW YORK PLaza 2-0885; 3555 W. Peterson Ave., CHICAGO 45, Ill., KEystone 9-1776; 2200 East Imperial Highway, EL SEGUNDO, Calif., ORegon 8-6226.*

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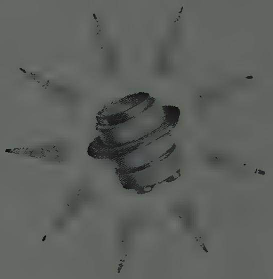
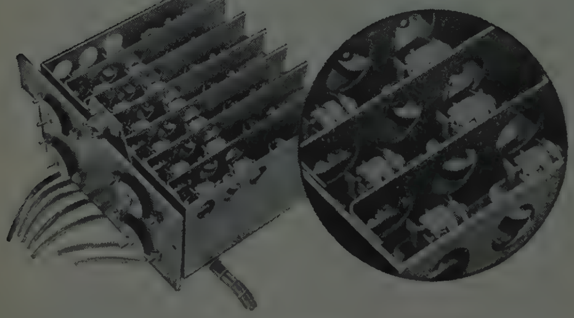


G-E 7077

over a wide spectrum o

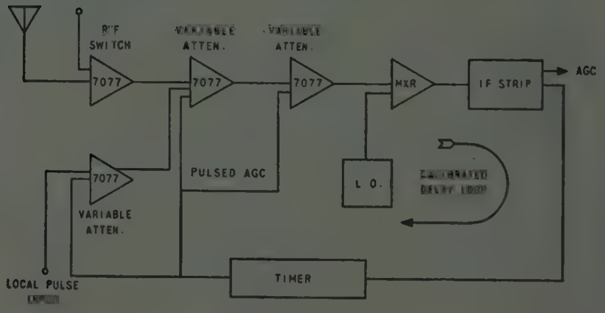
LOCKHEED



WIDE-BAND TAPE RECORDER.

For Lockheed, California Division, 28 General Electric 7077's serve as pre-amplifiers in a 14-channel 500-kc 60"-per-second tape recorder that stores wide-band information from an air defense exercise five times as rapidly as before. Extreme requirements of frequency, timing accuracy, and reproducibility are met by the 7077's low noise, high impedance, and high G_m. Also, the tube's small size matches the miniaturization needs of the Lockheed tape-recorder equipment.

MOTOROLA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VARIABLE ATTEN.
VARIABLE ATTEN.
7077
7077
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L.O.
CALIBRATED DELAY LOOP
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GROUND-SURVEYING RADAR.

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ısing ceramic tubes.
meets designers' targets
frequency and function.

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GENERAL ELECTRIC

Whom and What to See at the Radio Engineering Show

(Continued from page 364A)

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See: Douglas Microwave Co., Inc.

Spectrol Electronics Corp., Subsid. Carrier Corp., Booths 1907-1909
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Sperry Microwave Electronics Co.
Division Sperry Rand Corp.
Clearwater, Fla.
Booth 2438

E. C. Best, J. Newitt, ▲ G. Eckert, F. Lavelle, ▲ D. Wells, ▲ P. Ely, P. Thomas, J. Duffy, ▲ R. Greenwood, ▲ B. Duncan, D. Mirabella

Microline Direct Reading Frequency Meter

Complete line of Microwave Test Instruments, Microwave Components, and Electronic Test Instruments, Ferrite Isolators and Solid State Devices.

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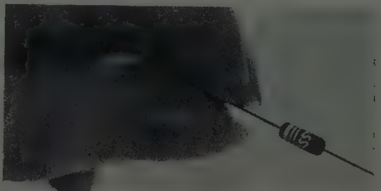
▲ Dr. W. R. Sittner, ▲ A. M. Varnum, W. M. Montgomery, Jr., G. C. Smith, L. C. Grannis, ▲ S. Weiner, ▲ R. H. Youden, J. Maechtlen, ▲ E. G. Shower, D. MacDonald, S. M. Grafton



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See also: Dynacor, Inc., Booth 4020

Stability Capacitors Ltd. (SRC), Booth 1820

See: British Radio Electronics, Ltd.

Standard Electric Time Corp., Booth 3021
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▲ Donald H. Locke, ▲ E. S. White, A. E. Bishop, P. H. Holden

*New Digital Readout Precision Timer—accurate to .01 sec. with instant electric reset. Other dial readout precision timers with accuracies to .001 second. Standard and custom models on display.

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Standard Electronics Div., Booths 1202, 1301-1303

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Standard Pressed Steel Co., Booth 4127
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Standard Pressed Steel Co.: C. J. Betz, C. Candy, G. Eberle, J. E. Harkins, M. Moorhouse, E. D. Otto, J. F. St. Pierre, A. W. Scott, W. A. Tait; International Electronic Industries, Inc.: A. M. Rowley

SPS—Socket screws (Plain and self-locking); self-locking locknuts and clinch nuts; steel collars; miniature socket screws, locknuts, clinch nuts and collars; high strength precision aircraft fasteners; *semiconductor materials; spring pins; steel shelving and shop equipment. I.E.I. Inc.—*Miniature and sub-miniature capacitors (aluminum and tantalum foil).

State Labs., Inc., Booth 2238

See: The Ericsson Corp.

Steel Co., Herman D., Booth 4034

See: Swiss Jewel Co.

Stepper Motors Div., Land-Air, Inc., Booth 1600
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Clarence Adams, Mark H. Hager

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Joseph Richards, Vincent Giagni, Martin Hoffman, Thomas McMahon, George Browning, Robert Howse, Joseph Solari

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(Continued on page 370A)

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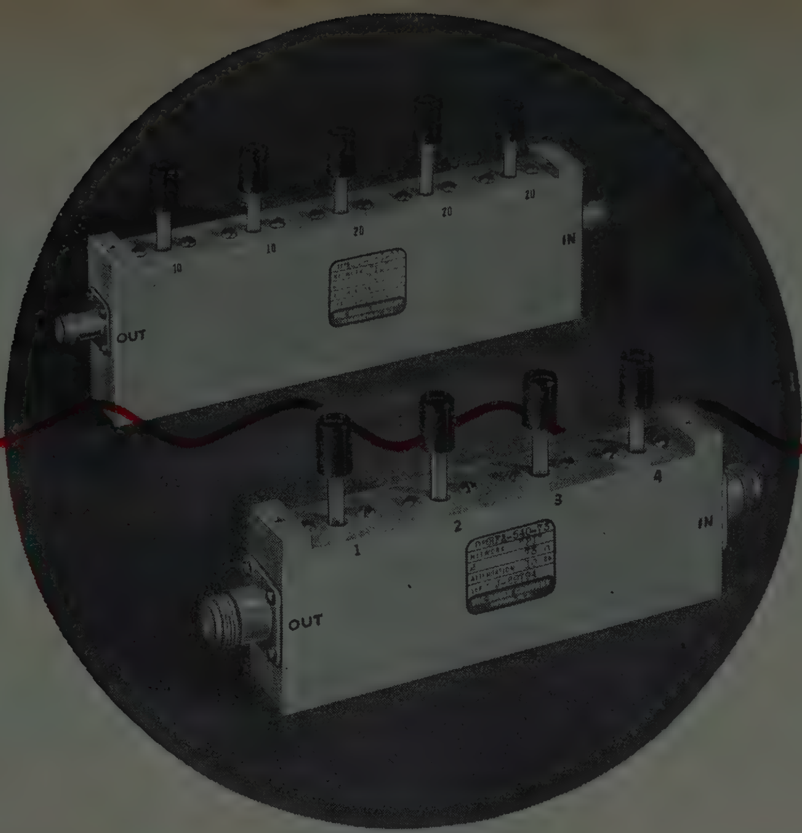

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RF Attenuators by DAVEN

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Many of these types are available for delivery from stock.

Solenoid actuated RF Attenuators are also available in various decibel combinations and any number of steps up to 5.

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RFA & RFB 540	1, 2, 3, 4 Db	10	50/50Ω and 73/73Ω
RFA & RFB 541	10, 20, 20, 20 Db	70	50/50Ω and 73/73Ω
RFA & RFB 542	2, 4, 6, 8 Db	20	50/50Ω and 73/73Ω
RFA & RFB 543	20, 20, 20, 20 Db	80	50/50Ω and 73/73Ω
RFA & RFB 550	1, 2, 3, 4, 10 Db	20	50/50Ω and 73/73Ω
RFA & RFB 551	10, 10, 20, 20, 20 Db	80	50/50Ω and 73/73Ω
RFA & RFB 552	2, 4, 6, 8, 20 Db	40	50/50Ω and 73/73Ω

Other Db loss combinations are available.

Write for complete information

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Whom and What to See at the Radio Engineering Show

(Continued from page 368A)

Stevens-Arnold, Inc.

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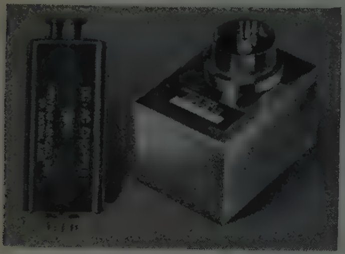
South Boston 27, Mass.
Booth 2934

Ezra Stevens



Stevens-Arnold Modulators

DC-AC Choppers, Ultra-High Speed Relays, Frequency Sensitive Relays, Vibrating Reed Capacitance Modulators. Pictured Above: Twin Contact DC-AC Chopper & Low Drift Vibrating Reed Capacitance Modulator. *DC Drive Choppers.

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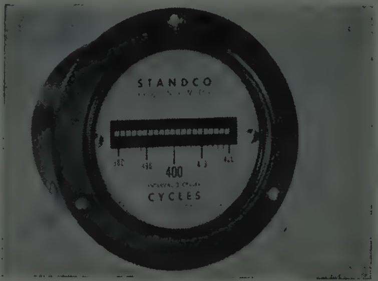

Vibrating Reed Frequency Meter

High Intensity Stroboscope, "Vibron" Vibrating Condenser Electrometer exceptional zero stability & accuracy, VHR Megohmmeter range 100 million megohms. Model 29A Megohmmeter. (20 Million Megohms). MEGOHMER Insulation Testers. "STANDCO" Vibrating Reed Frequency Meters. "CHRONOTEST" Millisecond, Microsecond Meters. Electro-magnetic Stop Watches. Tachometers, STATIGUN (static measuring instrument). Elapsed Time Meters.

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Stromberg Time Corp., Booth 1726A

See: General Time Corp.

R. H. Sturdy Co., Inc., Booth 1627

See: C & K Components, Inc.

Superior Electric Co.

83 Laurel St.
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Booths 2722-2732

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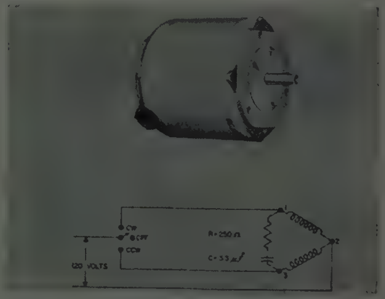

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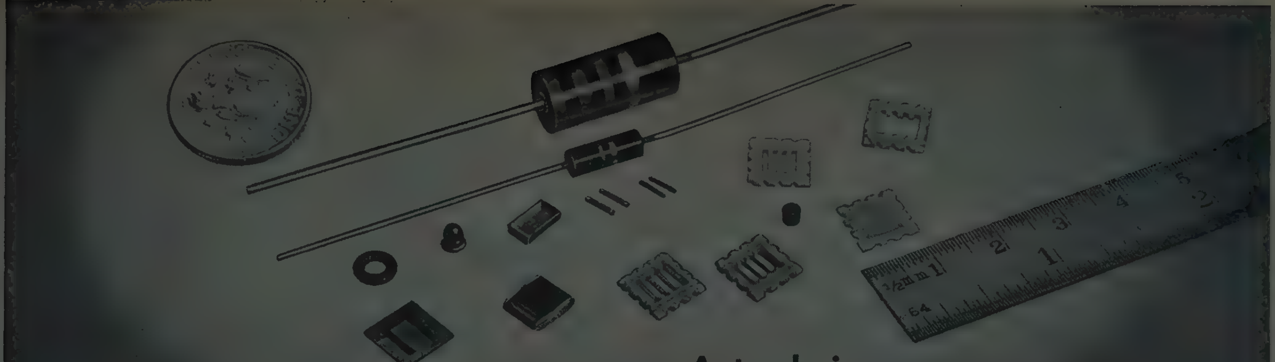
Electronic Equipment Engineering, the only monthly magazine devoted exclusively to electronic research and design offers special Product Directory Section listing exhibitors by product with new products described and keyed with inquiry numbers. . . . Miniaturization Award Winners (first four) will be on display.

(Continued on page 372A)

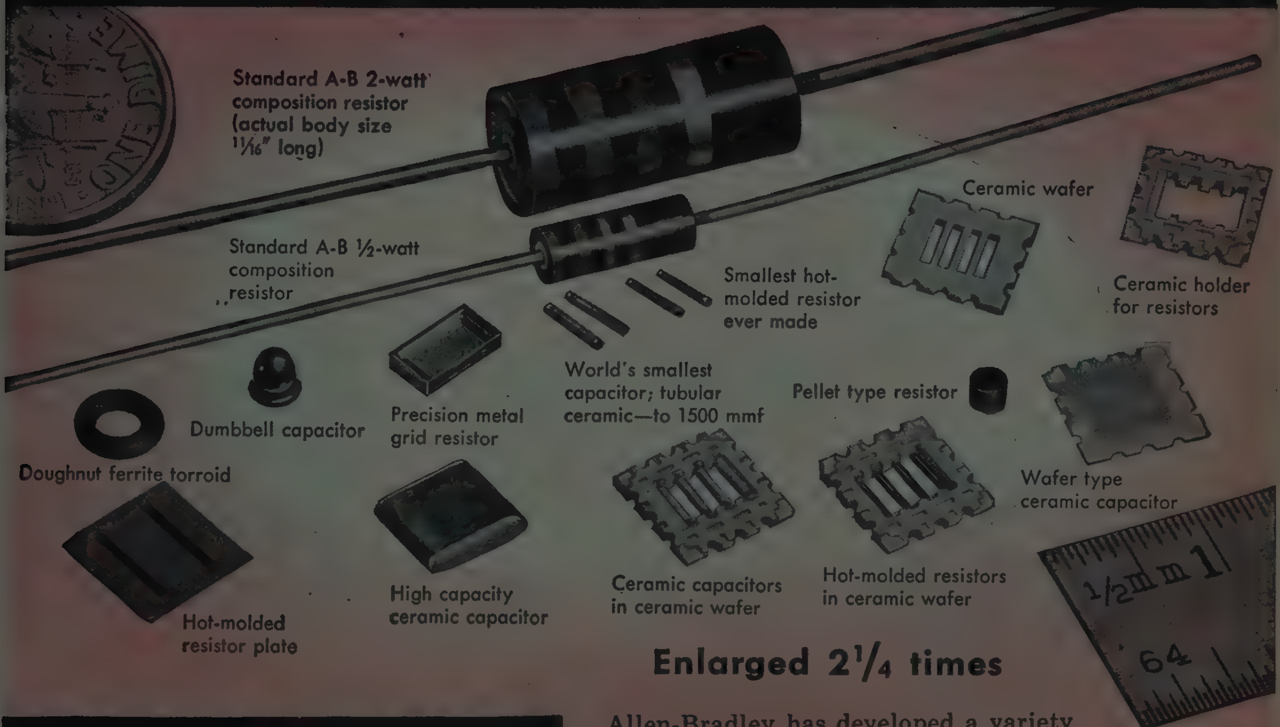
▲ Indicates IRE member.
* Indicates new product.



Actual size

Micro-Miniature Components

with traditional Allen-Bradley Reliability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Smallest hot-molded resistor ever made
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Whom and What to See at the Radio Engineering Show

(Continued from page 370A)

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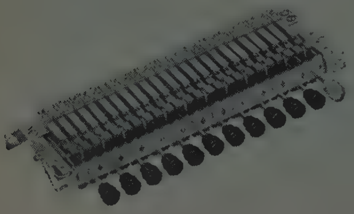
Lafayette Building, 5th & Chestnut Sts.
Philadelphia 6, Pa.

W. W. Woolford, P. N. Steel, Jr.

Swiss Jewel Company: Sapphire Jewel Bearings and Products. Herman D. Steel Company: Precision components, Swiss Screw Machine Products, Pinions, Gears, Pivots, and Clockwork Mechanisms.

Switchcraft, Inc.
5555 N. Elston Ave.
Chicago 30, Ill.
Booth 2827

W. L. Larson, W. E. Dumke, F. O. Dumke, W. G. Butler, P. G. Anderson, T. L. Dowell, J. Bailey



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"Multi-Switch" available with illuminated or non-illuminated push buttons. Unusual choice of functions. Can be mounted in stacks with interaction between buttons. Many other features. . . . Complete line of Plugs, Jacks, Switches, Audio Accessories.

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Microwave Diodes
100 Sylvan Rd.
Woburn, Mass.
Booth 2330

R. Ross, P. Trespas, W. Kelley, R. Swanson, G. Feldman

Testing of Sylvania Varactors

Live probe testing of varactor (variable capacitance) diodes a feature of Sylvania's semiconductor display. Reverse characteristics of mesa parametric amplifier diodes taken from whisker type probe and shown in oscillograph pattern (above). Eighteen parametric amplifier diodes in Sylvania line (D4075 & D4110, A through H). Frequency operation from 20 to 100 kmc.

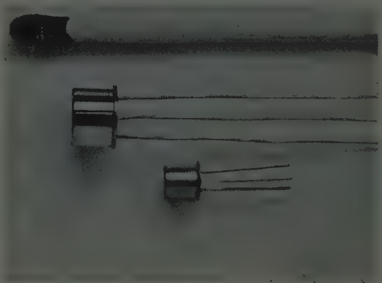
Sylvania Electric Products Inc.
Picture Tube Operations
1740 Broadway
New York 19, N.Y.
Booths 2322-2328, 2415-2425

C. Jacobs, A. W. Keen, B. Kievit, R. G. Lynch, R. S. Mason, G. Sheehy, R. R. Shields, R. A. Starek, J. C. Taylor, D. R. Welsh, D. Hughes, R. Sparnon

Low-heater power (1.5 Volt-140ma) CRT—Type 2751—capable of operating from ordinary flashlight battery—ideally suited for portable oscilloscope, radar and monitor applications; employs lightweight design and requires only 1⁄16 of power necessary to operate conventional 6.3 Volt-600 ma heater

Sylvania Electric Products Inc.
Transistors
281 Main St.
Wilmington, Mass.
Booth 2332

E. Schlener, J. Grant, J. Sweeney, J. Kolp, D. Tolins



Mesa transistors (lower illustration in picture above) for use in high-speed switching applications offer 75 millimicroseconds turn on time, 100 millimicroseconds storage time, & 100 millimicroseconds fall time. Germanium alloy junction type (center) is a 40 volt high-speed 2N576A with rise time of 1.0 microseconds, storage time of 0.5 microseconds & fall time of 0.5 microseconds.

▲ Indicates IRE member.
* Indicates new product.

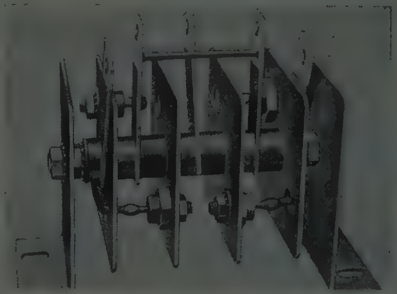
Synthane Corporation, Booths 4521-4523
12 River Road
Oaks, Pa.

R. B. Galloway, C. L. Johnson, H. Widdop, M. Price, H. Weiss, M. B. Firehock, V. Nickerson, J. Quinn, J. K. Johnson, F. W. Hansell, D. Garrison, R. Palmer

High pressure laminated plastics—sheets, rods, tubes—molded laminated and molded forms—copper clad laminates for printed circuits. *High temperature resistant phenolic laminates.

Syntron Company
Div. Link Belt Corporation
Homer City, Pa.
Booth M-10

J. I. Scott, R. P. Muldoon, ▲ N. P. Bosted, Homer E. Lytle, ▲ Milton Nelson, P. E. Myers, S. E. Brayshaw, ▲ Ted Suito

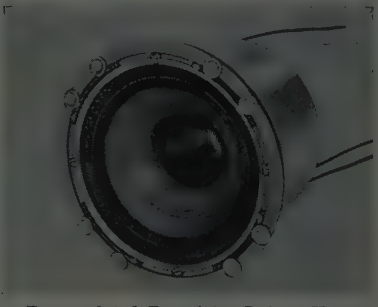


Silicon Rectifier Power Stack

Selenium Power Rectifiers, from 1″ × 1″ to 12″ × 16″ cells and stacks—Selenium Cartridge-type Rectifiers, in half-wave, doubler and bridge types—Silicon Power Rectifiers, and diodes rated from 500 m.a. to 250 amperes. Also stack and bridge configurations up to 1,000 amperes.

Syntronic Instruments, Inc.
100 Industrial Road
Addison, Ill.
Booth 2711

Dr. Henry Marcy, Robert Bank, Eugene Jenzen, George Harris



Encapsulated Transistor Driven Yoke

Deflection Yoke Specialists, Unusual types on display. Newest developments in custom designed yokes and production quantity yokes. Complete line for all cathode ray tubes including display, storage, character, miniature types. Focus coils for precision requirements.

Systron Corporation, Booth 3811
950 Galindo St.
Concord, Calif.

James R. Cunningham, George H. Bruns, Art Rippeon

*Transistorized 10 megacycle Counter Timer featuring low power, three DC amplifiers, IN-LINE readout. *High Speed Electronic Digital Voltmeter; True RMS to DC Converter, 2½ lb rack mounted. *Dual Potentiometer Recorder, zero to 1 MC IN-LINE Counters.

Tapco Group, Booths 1431-1631
See: Thompson Ramo Wooldridge, Inc.

(Continued on page 374A)

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Every one of the more than
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Microwave
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This busy metropolitan area is the termination of over 1000 miles of microwave systems, providing reliable communications across town and country for the Western Union Telegraph Company. ANDREW's experience in research, development and manufacturing is the reason why the dependable performance of an ANDREW PS8-37, eight-foot Parabolic antenna was selected for this installation.

All ANDREW parabolic antennas conform to the newly proposed EIA-FCC standards governing radiation patterns and side lobes, and they are *guaranteed* to give specified pattern and VSWR in your microwave system.

From a selection of over thirty stocked parabolic antennas, you can choose the type and size that will give optimum system performance with absolute mechanical and electrical reliability.

Microwave engineers have found ANDREW a valuable partner in planning their communication systems. A parabolic antenna computer for calculating system performance is available to you upon request. Write today for information and expert advice relative to your microwave antenna system requirements.

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Whom and What to See at the Radio Engineering Show

(Continued from page 372A)

Tape Cable Electronics Co., Inc., Booth 4431
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Rochester 10, N. Y.

Bob Smith

Flat conductor cable—light weight, space saving—especially applicable for printed circuit interwiring. Available with resistance alloys for heater applications. Selectacon (T) harness technique—for automating cable assemblies. Display of available connectors. Demonstration of handling techniques and capabilities.

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Telephone and Hospitality Center

South American Room
First Mezzanine
Entrance at
20 West 60th Street

Sarkes Tarzian, Inc., Semiconductor Div.

415 N. College Ave.
Bloomington, Ind.
Booth 1730

S. Tarzian, S. Niciejewski, W. Petrosky, F. Lucas, H. Anderson, E. Riggs, E. Chadwick

Tarzian exhibit features a complete line of silicon rectifiers and other semiconductor devices, current ratings from 150 ma. to 1000 amperes and voltage ratings from 50 to 10,400 (in assembly) volts. Also showing selenium rectifiers, magnetic tape and television tuners.

Tech Laboratories, Inc.

Bergen & Edsall Blvds.
Palisades Park, N.J.
Booth 2120

Gerrit J. Van Baaren, J. G. Douglas, Elton Nachman, M. Bjorndal

Attenuators, Instrument and control switches of all kinds, cam switches, solenoid and motor driven switches and special test equipment.

Technical Appliance Corp.

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▲ H. H. Brown, ▲ Tore Lundahl, ▲ Robert T. Leitner, ▲ Albert K. Fowler, Douglas Vining, ▲ George Sleeper

Antenna systems including complete installation. Antennas point-to-point, ground based, airborne, television. R.F. development to specific needs. Complete engineering, manufacturing and test facilities including 3000′ long range test site equipped with automatic recording equipment and major support structures.

Technical Devices Company, Booth 4233
5658 South Rudman Drive
Culver City, Calif.

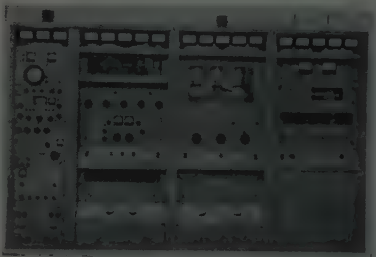
Melvin K. Allen, Raymond Roe, Perry Lohse, Ringland Krueger, Eileen O'Brien

Production equipment specifically for electronics manufacturing. Automatic and semi automatic machines and hand tools. Mark V Component Lead Former, Mark II Wire Cutter & Stripper, T. D. Circuit Board Fixture, Shielded Wire Lead Extractor.

Technical Materiel Corp.

700 Fenimore Road
Mamaroneck, N.Y.
Booths 3702-3706

▲ W. J. Galione, E. A. Matson, Jr., ▲ W. L. Deans, ▲ D. W. Carter, D. B. Craft, ▲ H. J. Geist, W. C. Shalag, ▲ M. K. Yurko, ▲ D. J. Hillman, ▲ Paul Munroe, Jack Caputo, Harry Ashdown



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Single Sideband Transimitters 1 to 40 KW*; Single Sideband Receiving Systems; Complete Communications Packages; Frequency Synthesisors*; Transmitting & Receiving Antenna Systems; Sideband Diversity Systems*; Multicouplers; Broadband Transformers; Antenna Tuning Systems; Remote Controlled Transmitters & Receivers; Complete Engineering Systems.

Technical Wire Products, Inc., Booth 4129
48 Brown Ave.
Springfield, N. J.

▲ O. P. Schreiber, ▲ Stewart Nellis, M. S. Pringle, R. L. Hartwell

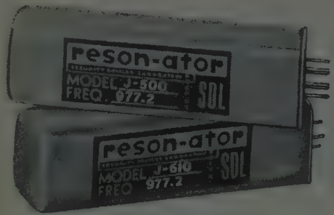
TECKSTRIP RFI (Radio Frequency Interference) gasketing, and integrated RFI gasket and mounting system for easier handling and installation. Complete gasket RFI engineering assistance from leaders in the field. See our complete line of standard and custom made RFI gasketing products.

Technicraft Labs., Inc., Booth 1818

See: Electronic Specialty Co., Technicraft Div.

(Continued on page 376A)

reson-ator
FREQUENCY SELECTIVE DEVICES



RESONANT REED RELAYS AND OSCILLATOR CONTROLS

Reson-ator Resonant Reed Relays and Oscillator Controls are precision electro-mechanical devices engineered to provide the finest, most economical method of detection and generation of frequencies in the audio range. Ideal for any application requiring the stability and long life characteristic of this tuning fork type device.

Brief Specifications—

Frequencies: 20 cps to 1600 cps
Coil Resistances: 1 to 1500 ohms DC
Temperature stability: ±.0025%/C °from −40°C to +100°C.
Reference 25°C
Enclosure: Drawn copper can, .750″x .750″x3.281″ overall. Provided with standard 7 pin hermetic seal header.
Relay Bandwidths: To suit customer's requirements. From ±.1% to ±4%
Complete specifications and application data available upon request.

- SIGNALING SYSTEMS
- DATA TRANSMISSION
- TONE GENERATORS
- FREQUENCY STANDARDS
- REMOTE CONTROL
- FREQUENCY DETECTION
- AUDIO FILTERS
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ELECTRONICS DIVISION OF SARGENT & GREENLEAF, INC.
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switching
use RAYTHEON
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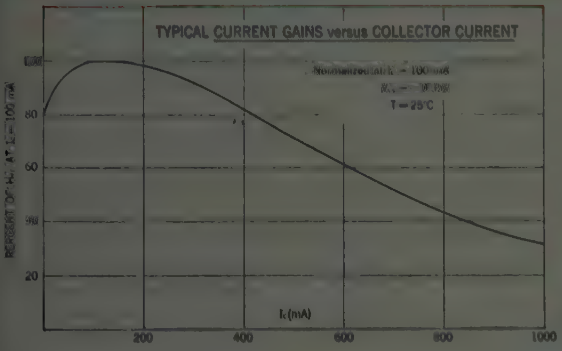
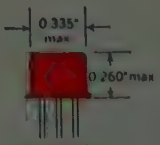
RELIABLE COMPUTER TRANSISTORS





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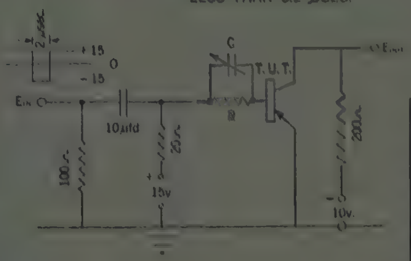
TYPICAL COMPENSATING CAPACITY VALUES FOR STORAGE TIMES LESS THAN 0.2 µSEC.



Type	R kil ohms	C µµf
2N658	3.9	120
2N659	6.0	100
2N660	9.1	80
2N661	12.5	40
2N662	4.5	110

Type	Punch through Voltage max.	f_{ab} ave. Mc	H_{FE} ave. I_C = -50 mA V_{CE} = -0.35v	H_{FE} ave. (1) I_C = -200 mA (2) I_C = -400 mA V_{CE} = -0.50v	I_{co} at -12v µA	r_b' I_c = -1mA ohms	C_{ob} V_{cb} = -6v µµf
2N658	-24	5	50	(1) 45	2.5	60	12
2N659	-20	10	70	(1) 65	2.5	65	12
2N660	-16	15	90	(2) 75	2.5	70	12
2N661	-12	20	120	(2) 100	2.5	75	12
2N662	-16	8	30 min.	(1) 65	2.5	65	12

Typical values at 25°C unless otherwise indicated

Dissipation Coefficients: In air 0.35°C/mW; Infinite Sink 0.18°C/mW

These new PNP Germanium Computer Transistors made by Raytheon's reliable *fusion-alloy* process add to the already comprehensive line of Raytheon Reliable Computer Transistors which include several in the *Submin* (0.160" high, 0.130" dia.) package. Write for Data Sheets.

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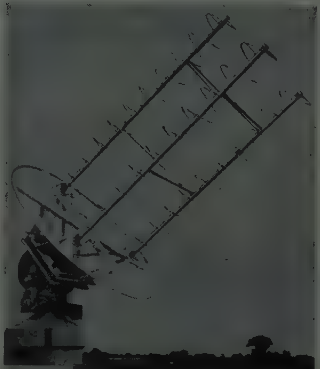
Doploc antenna system for tracking orbital bodies. Designed, produced and installed by Taco.

Taco offers capabilities in practically every antenna and antenna system area. These capabilities include conception, development and production, as well as field erection of antennas for all purposes. In addition, Taco offers a complete line of parabolic reflectors ranging from 4′ to 32′, along with all types of feed systems, ruggedized yagis, helical antennas with or without reflectors, airborne and submarine antennas, and complete tracking systems.

Whatever your antenna needs, check with Taco first . . .

SEE TACO—BOOTH 1101—
NEW YORK I.R.E. SHOW



Taco telemetering antennas for all commercial and military needs.

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SHERBURNE, NEW YORK

Whom and What to See at the Radio Engineering Show

(Continued from page 374A)

Technology Instrument Corp., Booths 2317-2319
531 Main St.
Acton, Mass.

▲ Hollis L. Gray, Jr., ▲ David Lawton, Elmer Burns, ▲ Darrel Gustafson, Al Vanderhoof, George McClarity

The New Rotoflex® multi-million-cycle-life wirewound precision potentiometer*. Potentiometers—single and multiturn wirewound and film element, rotary and box trimmers, panel controls, precision servo type, special non-linears, displacement and pressure transducers, switches, commutators, clutch, brake, and spring return units. Hermetically sealed film pots and conductive plastics.

Tektronix, Inc.
P.O. Box 831
Portland 7, Ore.
Booths 3027-3030

▲ Dan Guy, Dale Brous, Fred Lenczynski, John West, Bill Ewin, ▲ Scotty Pyle, ▲ Bill Kladke, ▲ Bill Polits, ▲ Dick Rhiger, ▲ John Kobbe, ▲ Norm Winningstad, ▲ Byron Broms

DC to 1 KMC Oscillocope

New Low-Frequency Oscilloscope, New Low-Frequency X-Y Oscilloscope, New Current Probe, New Module Oscilloscope, New Pulse-Sampling System for Tektronix Plug-in Oscilloscopes, New Transistorized Portable Oscilloscope, New Wide-Band Amplifier, New High-Current Supply for Type 575 Transistor Curve Tracer.

Telechrome Mfg. Corp., Booths 3612-3614
28 Ranick Drive
Amityville, L. I., N. Y.

H. Charles Riker, ▲ J. R. Popkin-Clurman, S. Dubin, D. Dudley, J. Reeves, E. Herman, George Fried, Al Schneider

Video Transmission Test Equipment, *New TV Special Effects Generator, Telemetering Transmitters, RF Amplifiers, Analog to Digital Converters, Radiation Detection Equipment, Transistorized P.S., Automation Control Equipment, Telegraph Tone Channel Equipment.

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(Continued on page 378A)

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* Indicates new product.

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FREED QUALITY

Ruggedized, MIL STANDARD
OWER & FILAMENT TRANSFORMERS

Primary 105/115/125 V 50-60~

t. No.	Appl.	MIL Std.	MIL Type
GP 1	Plate & Fil.	90026	TF4RX03HA001
GP 2	Plate & Fil.	90027	TF4RX03JB002
GP 3	Plate & Fil.	90028	TF4RX03KB006
GP 4	Plate & Fil.	90029	TF4RX03LB003
GP 5	Plate & Fil.	90030	TF4RX03MB004
GP 6	Plate	90031	TF4RX02KB001
GP 7	Plate	90032	TF4RX02LB002
GP 8	Plate	90036	TF4RX02NB003
GF 1	Filament	90016	TF4RX01EB002
GF 2	Filament	90017	TF4RX01GB003
GF 3	Filament	90018	TF4RX01FB004
GF 4	Filament	90019	TF4RX01HB005
GF 5	Filament	90020	TF4RX01FB006
GF 6	Filament	90021	TF4RX01GB007
GF 7	Filament	90022	TF4RX01JB008
GF 8	Filament	90023	TF4RX01KB009
GF 9	Filament	90024	TF4RX01JB012
GF 10	Filament	90025	TF4RX01KB013

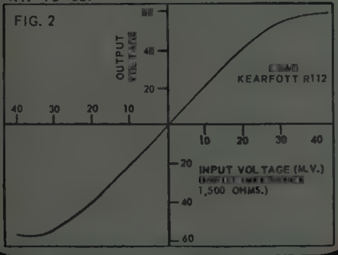
MAGNETIC AMPLIFIERS

- Hermetically Sealed To MIL Specifications
- No Tubes
- Direct Operation from Line Voltage
- Fast Response
- Long Life Trouble Free Operation
- Phase Reversible Output

Power Gain 2 x 10⁸

Transistor Preamp. MAT-1 Wt. 10 oz.	Mag. Amp. MAF-5 Wt. 18 oz.	Motor

FIG. 2



TOROIDAL INDUCTORS

- MIL Grade 4 — Metal Case
- MIL Grade 5 — Molded
- Uncased Units
- Highest Q
- Highest self resonant freq.
- Low temperature coefficient
- No hum pickup-astatic construction
- Can be supplied with center taps

FREQUENCY RANGE: 500CP TO 15KC

Type	Max Q	Inductance Range
TI-11	290	1MH to 50Hy
TI-12	255	1MH to 30Hy
TI-1A	250	1MH to 30Hy
TI-1	210	5MH to 20Hy
TI-4	195	5MH to 5Hy
TI-5	130	5MH to 2Hy
TI-16	72	1MH to 2Hy

FREQUENCY RANGE: 10KC TO 50KC

Type	Max Q	Inductance Range
TI-13	303	1MH to 500MH
TI-2	285	1MH to 500MH
TI-6	279	1MH to 400MH
TI-7	200	.500MH to 200MH
TI-17	110	.100MH to 100MH

FREQUENCY RANGE: 30KC TO 200KC

Type	Max Q	Inductance Range
TI-18	115	.1MH to 100MH
TI-8	140	.1MH to 100MH
TI-10	185	1MH to 200MH
TI-9	175	1MH to 500MH
TI-19	100	.1MH to 5MH
TI-3	260	.1MH to 10MH
TI-3A	310	10MH to 100MH

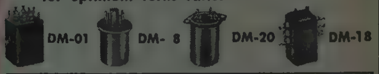
HIGH FREQUENCY TOROIDAL INDUCTORS

FREQUENCY RANGE: 20KC TO 10MC

Type	Max Q	Inductance Range
TI-21	205	.010MH to .150MH
TI-22	250	.010MH to .700MH
TI-23	210	.010MH to .500MH
TI-20	305	.050MH to 5MH

HERMETICALLY SEALED, MIL-T-27A PULSE TRANSFORMERS

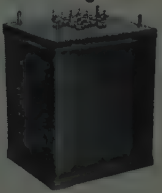
- Maximum power efficiency and optimum pulse performance.
- For use in blocking oscillator, interstage coupling and low level output circuits.
- Ruggedized construction — Grade 4.
- Series or parallel connection of windings for optimum turns ratio.



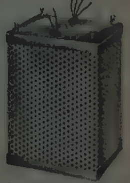
Cat. No.	MIL Type	Pulse Voltage Kilovolts	Char. Imp. Ohms
MPT- 1	TF4RX35YY	0.25/0.25/0.25	250
MPT- 2	TF4RX35YY	0.25/0.25	250
MPT- 3	TF4RX35YY	0.5/0.5/0.5	250
MPT- 4	TF4RX35YY	0.5/0.5	250
MPT- 5	TF4RX35YY	0.5/0.5/0.5	500
MPT- 6	TF4RX35YY	0.5/0.5	500
MPT- 7	TF4RX35YY	0.7/0.7/0.7	200
MPT- 8	TF4RX35YY	0.7/0.7	200
MPT- 9	TF4RX35YY	1.0/1.0/1.0	200
MPT-10	TF4RX35YY	1.0/1.0	200
MPT-11	TF4RX35YY	1.0/1.0/1.0	500
MPT-12	TF4RX35YY	0.15/0.15/0.3/0.3	700

NEW
HERMETICALLY SEALED CONSTANT VOLTAGE TRANSFORMERS.

Meets Military Specifications No Tubes No Moving Parts	Accurate Regulations Fast Response Fully Automatic



MIL Type



Commercial Type

Here at last is a hermetically sealed magnetic voltage regulator that will provide constant output voltage regardless of line and/or load changes.

SUPPLIED EITHER MIL. OR COMMERCIAL

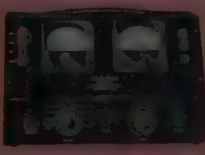
CAT. #	INPUT VOLT.	LINE FREQ.	OUTPUT VOLT.	OUTPUT VA.
MCV- 620L	95-130 v	60 cps.	115	20
MCV- 670L	95-130 v	60 cps.	115	70
MCV-6130L	95-130 v	60 cps.	115	130
MCV- 670F	95-130 v	60 cps.	6.4	70
MCV-6130F	95-130 v	60 tps.	6.4	130
MCV- 420F	95-130 v	400 cps.	6.4	20

FREED QUALITY INSTRUMENTS FOR PRECISION LABORATORY TESTING

NO. 1110-AB
INCREMENTAL INDUCTANCE BRIDGE

- Inductance: 1 Millihenry to 1000 Henry
- Maximum Direct Current: 1 Ampere

NO. 1620
VARIABLE TEST VOLTAGE MEGOHMMETER



- Variable DC test voltage: 50 to 1000 volts
- Resistance range: .1 megohm to 4,000,000 megohms

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Whom and What to See at the Radio Engineering Show

(Continued from page 376A)

Telectro Industries Corp., Booth 3241
35-16 37th St.
Long Island City 1, N. Y.

▲ Harry Sussman, ▲ Stanley Rosenberg, ▲ George Brown, Irwin Nadelbach, Werner Seelig, Abraham Feder, Edward Waldman, Samuel Sack, Max Weissbach, Ralph Kirlander

Magnetic tape recorders, transports and testing equipment. Tape transports and recorders for computers, automation, the armed forces and aviation industry. High fidelity magnetic recorders and transports. Video system for transmission and reception of broad band information over narrow band channels.

Telemeter Magnetics, Inc.

P.O. Box 329
Culver City, California
Booth 1900

▲ Edwin R. Gamson, R. David Miner, J. Todd Murphy, William W. Follin, Marvin N. Weitzenhoffer, ▲ Robert D. Schmidt, Richard A. Terry

TYPE RB—General Purpose Memory

Core memory products—*Type RB General Purpose Memory; Ferrite Cores; *Polyaperture Devices; Core Buffer Memory; *MIL-STAK Units; and Memory units for Military Applications.

Telerad Mfg. Corp.

1440 Broadway
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Booth 1427

Charles George, Edgar A. Kiely, Stephen Lebo, ▲ William Reichard, Walter Lupish, Jules Kottke, George Hall, A. Parker Terhune

New Compact Radar Beacon

*New Compact Radar Beacon. Model SRT-3081. Environmental Conditions: Temperature, 54° C TD 125°C; Vibration, 10 to 100 cps @ 25 G; Acceleration, 50 G; Altitude, 60,000 feet; Shock, 15 G—Receiver: Frequency range, 2750-2950 MC/Sec.—Transmitter: Frequency range, 2750-2950 MC/Sec. Microwave components and equipment built to military standards.

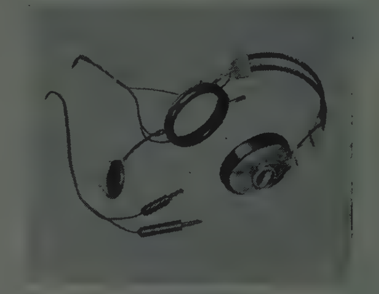
Teletronics Laboratory, Inc., Booths 3312-3314
See: Crosby-Teletronics Corporation

Telewave Laboratories, Inc., Booths 3205-3211
See: Polarad Electronics Corp.

Telex, Inc.

1633 Eustis St.
St. Paul 1, Minn.
Booth 2919

L. H. Josefson, K. McCrimmon, D. L. McNevin, ▲ R. L. Sell, R. F. Buelow



Dyna-Twin Headset, Boom Mounted Microphone

Headsets: Dynamic, Magnetic, Monaural and Stereo; Boom Headsets; Earphones; Pillow Speakers; Dynamic Microphones; Transformers: Miniature, Toroidal, Pulse; Miniature Amplifiers; Miniature Connectors; Computer Logic Modules; Miniaturized Push Button Switch Array General Purpose; Binary Encoded Output Development; Manufacturing Electronic Assemblies and Packaging.

Telonic Industries Inc., Booth 3022
60 N. First Ave.
Beech Grove, Ind.

L. W. Abbott

*Sweep Generators, Marker Equipment, *RF Attenuators, RF Detectors, RF Filters.

Telrex Labs.

Asbury Park, N.J.
Booth 1317

▲ M. D. Ercolino, Ralph Ercolino, Tom Igo, George Myers

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Temco Electronics, A division of Temco Aircraft Corp., Booth 3043
P.O. Box 6191
Dallas 22, Tex.

Stanley Grayson, Clifford Raber, Charles Harmon, Wally Graves, Jack Struble, Douglas McCroskey

Development and Manufacturing of Automatic Controls, Radiation Systems, Apparatus, Solid-State Devices and Instrumentation, DC-DC Converters, 3-Phase Static Inverters, Spiral Antennas.

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Temperature Engineering Corp.

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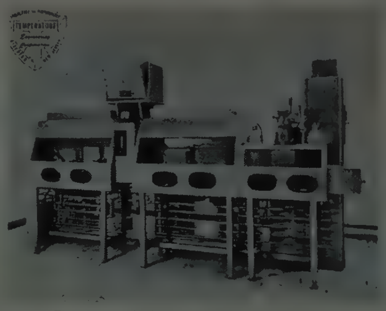
Riverton, N.J.
Booth 4134

Sidney H. Perlman, Norman Burstein, Barry Perlman, David Baum, Harold Ottbrini, Robert Harkins, Rolland Jenkins



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*Packaged controlled atmosphere enclosures, fabricated from steel or stainless steel—with welders, vacuum bakeout, test facilities and production flow for processing semiconductors, controlled rectifiers and other hermetically sealed components. *Packaged high vacuum pumping systems with vacuum ovens, *Evaporator-dry box, *soak ovens, *semiconductor and life test equipment.

Tempo Instrument Incorporated

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Hicksville, L.I., N.Y.
Booth M-8

George J. Sbordone, ▲ A. M. Multari, R. Peter, ▲ M. Poulos, J. Van Putten, ▲ F. Meyer

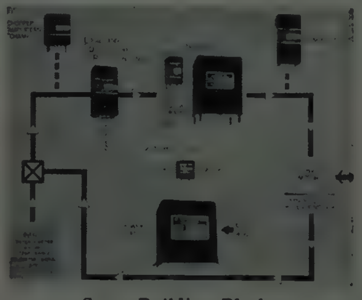
Solid State Timing Modules

Solid State Timing Devices and Controls. Logic and/or Timing Modules, Static Timers, Time Delay Relays, Voltage Sensors, Intervalometers, Flashers, Pulse Train Generators, Repeat Cycle Timers, Sequence Timers, Programmers, Hi-Accuracy Timers.

M. Ten Bosch, Inc.

80 Wheeler Ave.
Pleasantville, N.Y.
Booth 1620

M. ten Bosch, George Bannerman, Herbert Bredemeier, John Corneal, Raymond Frowd, Paul Lang, William Povall, James Taylor



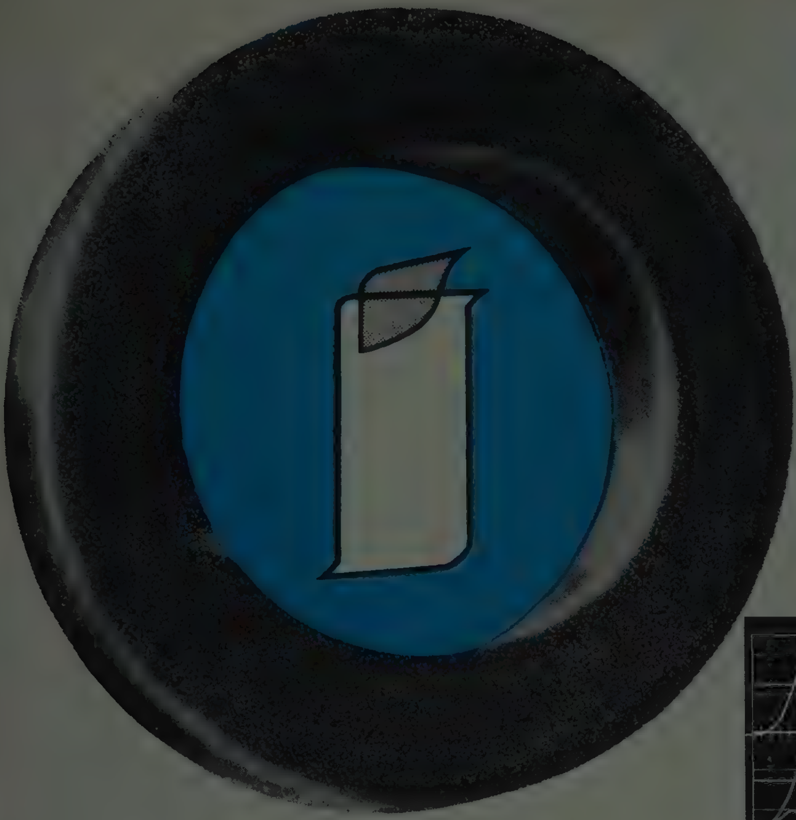
Servo Building Blocks

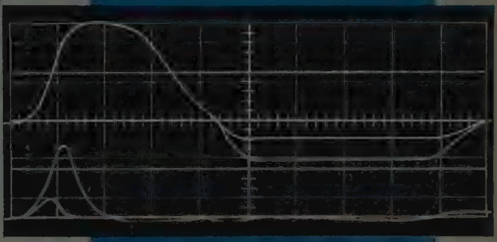
Assembling a Servo Loop for desired performance now made easy by selecting standard components; Transistor Amplifier, Power Supplies, Surge Limiters, and *new LQR unit allows stability at high gain and faster response than is possible with rate generators. Also showing Rotor Balancers, Integrators, Computers.

(Continued on page 380A)

Now...one microsecond

Complete Core Memory Cycle with TMI Word-Select Technique





Oscillogram showing drive pulse and switching time for TM 301-02 core. Time scale 0.02μs/division.

TMI pioneers again to make commercially available a newly developed advanced core memory product. Type LQ memory products provide a complete **clear/write** and **read/restore** memory cycle at rates to one megacycle, utilizing a new word-select design technique. These products are offered by Telemeter Magnetics in any form desired — from cores to complete memory systems.

Cores For those memory manufacturers who prefer to wire their own arrays, TMI word-select ferrite cores may be ordered now. These high speed cores provide extremely fast switching with low drive current.

Arrays and Stacks You may take advantage of the skill and production efficiency developed at TMI in manufacturing millions of cores, most of which have been assembled into arrays and memory stacks. This know-how is being applied to assembly of the new word-select cores into configurations to meet virtually any high speed computer design need.

Memories A new ultra-speed memory — the Type LQ — is available for commercial delivery in late 1960. Operating speeds up to 1.0 microsecond random access cycle time are now economical and result from the development of special ferrite cores and advanced driving and sensing circuits. The LQ word-select memory permits application to a wide variety of speed and capacity requirements.

VISIT US AT THE IRE SHOW BOOTH 1900

For complete specifications or to discuss your problem with a TMI applications engineer write or call

TELEMETER MAGNETICS Inc

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Data Equipment Division, 9937 Jefferson Blvd., Culver City, Calif.
® Components Division, 2245 Pontius Ave., Los Angeles, Calif.

PIONEERS IN DEVELOPMENT AND MANUFACTURE OF CORE MEMORY PRODUCTS

PEM

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• BOOTH 4518 •

Radio Engineering Show

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- WELD FASTENERS
- SELF-LOCKING and SELF-CLINCHING FASTENERS
- FLOATING FASTENERS
- FLUSH EXTERNAL and INTERNAL THREAD FASTENERS
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Model 802B Twin Transistorized Supply

EACH OUTPUT:

0-36 VOLTS

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PRICE $580.00

LINE REGULATION: Less than 5.0 millivolts
LOAD REGULATION: Less than 5.0 millivolts
RIPPLE AND NOISE: Less than 200 μv rms
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OUTPUT CONTINUOUSLY VARIABLE
REMOTE ERROR SENSING
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HARRISON LABORATORIES, INC.
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Whom and What to See at the Radio Engineering Show

(Continued from page 378A)

Tenney Engineering, Inc., Booth 3226-3228
1090 Springfield Road
Union, N. J.

Robert H. Brown, Frank Gardner, Martin S. Schletter, Fred Hermann, Thomas Warren, Glenn Cunningham, Fred Froelich, Leonard Rubin, Edward Kirchman, Edward Lavine, Avery Owen, Edward Boyer

*Hyper environment test facility—combining altitudes to 500,000 feet minimum, temperatures to a minimum of 1200°F, a refrigerated vapor trap operating in the range of —120°F and an automatic hot gas defrost. *Acoustical test chamber.

Tensolite Insulated Wire Co., Inc.
Subsid. Carlisle Corporation
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Tarrytown, N.Y.
Booth 4330

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6000 Lemmon Ave.
Dallas 9, Tex.
Booths 1409-1421

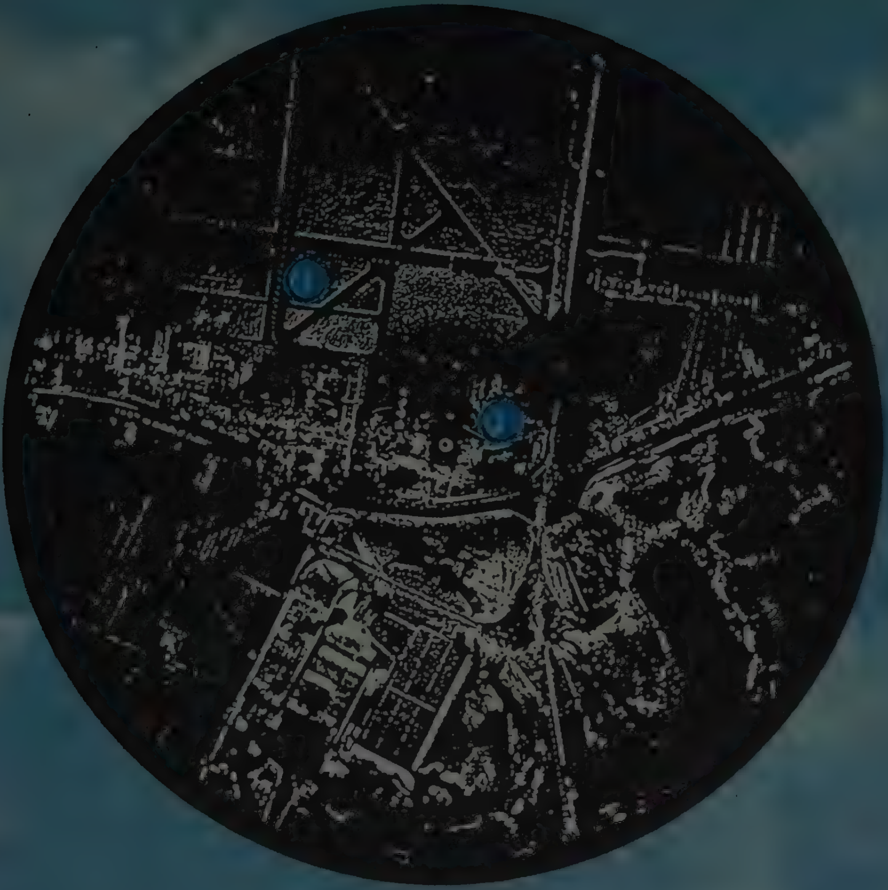
W. F. Joyce, J. Wissemann, A. Coulson, R. Bailey, R. Keener, K. Dowell, L. Strom, J. Zasa, R. Mitchell, J. Struneski, G. Dove, W. McGalliard

FM/FM Telemetry System

This FM/FM telemetry system will monitor Centaur space probes and lunar landings. Latest developments in radar*, infrared, digital apparatus*, telemetering, submarine detection, and surveillance systems.

(Continued on page 394A)

THE SHORTEST PULSE ON RECORD...



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Amperex
7093

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1 *jeep travelling down runway at 55 mph.*

2 *slow moving vehicles and people walking.*

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Hermes Electronics Co. is a unique organization where responsibility and initiative are encouraged. Here you will also find the stimulation and environment of a young and growing company. Your association will be with staff members who are in the vanguard of many of today's rapidly expanding technical frontiers.

Salaries and other benefits are comparable to those of major research and development organizations. The company's location in Cambridge, Mass. affords unequaled cultural, living, and recreation facilities. Liberal educational benefits are allowed for graduate study at leading universities in this area.

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Hermes Electronics Co.

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Positions Open

The following positions of interest to IRE members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. ....

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

Proceedings of the IRE
1 East 79th St., New York 21, N.Y.

ENGINEERS

ASSISTANT DIRECTOR RESEARCH & DEVELOPMENT: E.E. graduate with an advanced degree, who has history in electronics, audio, transducers, pulse circuitry and electromechanical devices. Supervisory experience desired in organizing and planning R&D programs.

CHIEF RESEARCH ENGINEER: Electronic engineering graduate trained in audio, video and transistor circuits. Supervisory experience in R&D planning.

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SENIOR & JUNIOR ELECTRONIC ENGINEERS will find ample opportunities and challenges in Gray Manufacturing Co., 16 Arbor St., Hartford, Conn.

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Assistant Professor of Electrical Engineering, University of North Dakota, Grand Forks, North Dakota. Position open September 1960. Must have M.S. degree and some experience in teaching or industry. Will teach electronic and circuitry courses to undergraduates primarily, with some graduate teaching available, if desired. Submit resume to Chairman, Electrical Engineering Dept.

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Assistant & Associate Professors, Ph.D., 200 graduate students. Ideal dry mountain climate. Income $10,000 up with research. Chairman, E.E. Dept., University of New Mexico, Albuquerque, New Mexico.

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A high level staff engineering position is available for an experienced engineer who desires a position without line responsibilities. The position requires ability to study systems and circuits proposed and under development with a view to steering engineering effort along productive paths. A superior educational background and considerable experience are required in carrier telephone, electronic switching, microwave systems, and related circuitry. Salary open. Northern California area. All replies will be kept confidential. Reply to Box 2008.

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(Continued on page 384A)

COMPUTER SYSTEMS SUPERVISOR

We are seeking an engineer with a record of outstanding achievement in research and development to direct the activities of our Computer Systems Section. As supervisor of this important activity, you will have the opportunity to develop research programs of greatest appeal to you and your staff in the following areas:

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- Advanced Development
  - Digital System Organization
  - Logic
  - Storage
  - Input/Output
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As a Foundation staff member you will be joining a mature, independent research organization with a staff of over 600 engineers and scientists contributing to a wide variety of military and industrial research programs.

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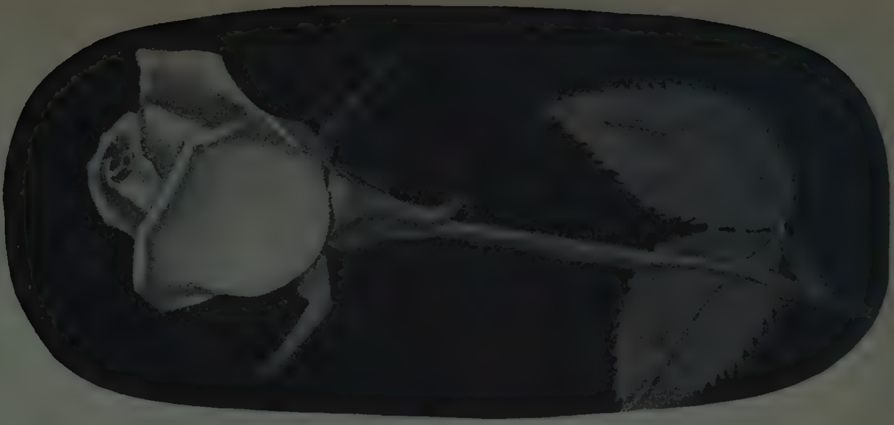

At Bendix York, we have a number of immediate openings for Electronic Engineers and Physicists.

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The white rose is a symbol at Bendix York . . . a symbol with two meanings. Both of vital importance to *your* future.

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On these dates only, call:
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Or for interview on other days,
Send resume or call collect:
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Barnes Engineering Company
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STAMFORD, CONNECTICUT

Positions Open

(Continued from page 382A)

MICROWAVE SPECIALIST

Microwave physicist needed for applying microwave techniques to the study of plasma flows and ionized regions around high speed models and in shock tubes. Measurements and study of the radio-frequency energy emitted by the passage of high-speed models and of the transmission and reflection characteristics of the wake are required in order to evaluate the effects of these characteristics and also as an aid to further the knowledge of flow phenomena at extreme speeds. Applicant should have advanced degree with a good background in microwave propagation and field theory as well as ability to work with microwave hardware. He should be capable of taking the initiative in the application of microwave techniques and in the interpretation of results. Write Personnel Officer, NASA, Ames Research Center, Moffett Field, Calif.

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Young Electronic Engineer, experienced in circuit design, to work as assistant to one of the outstanding engineers in the country in the design and development of precision analog equipment. This is once-in-a-career opportunity for the right individual to learn from one who has, over the past 15 years, established a proven record of accomplishment in the analog field. Apply Milgo Electronic Corp., 7620 N.W. 36th Ave., Miami 47, Florida.

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Staff openings for September 1960 in Electrical Engineering Dept. Mostly undergraduate instruction. Attractive salary, living conditions. Recreation center of the West. Correspondence invited. I. J. Sandorf, Chairman, Dept. of E.E., University of Nevada, Reno, Nevada.

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The University of Alaska has an opening for an Assistant Professor of Electrical Engineering—to teach and do research on the ionosphere, the aurora, or on problems in communications or power in the North. Industrial experience or advanced degree required. Write Airmail to Dept. of E.E., University of Alaska, Box 497, College, Alaska.

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Engineering or Physics degree. 5-10 years experience in inertial guidance systems and/or components. Aid in developing concepts of advanced guidance systems and in promulgating written and verbal communications on the subject to other groups in allied fields. Send resume to G. A. Nesbet, Litton Industries, Beverly Hills, Calif.

RESEARCH SCIENTIST

Physics degree, advanced preferable. Experienced in thermodynamics, cyrogenics, vacuum technology, optics. Aid in developing space stimulation techniques. Send resume to G. A. Nesbet, Litton Industries, Beverly Hills, Calif.

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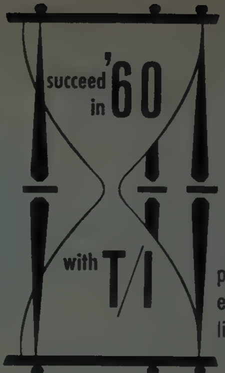
Opportunities at Robert College, Istanbul, Turkey for qualified men in civil engineering or mathematics, interested in combining teaching and the development of limited research and consulting activities with the opportunity to live in a vital part of the world: strengthening staff, modernizing undergraduate curricula, beginning grad-

(Continued on page 387A)



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see full-page ad page 395A

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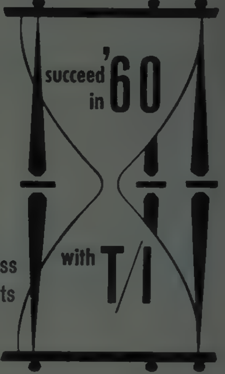

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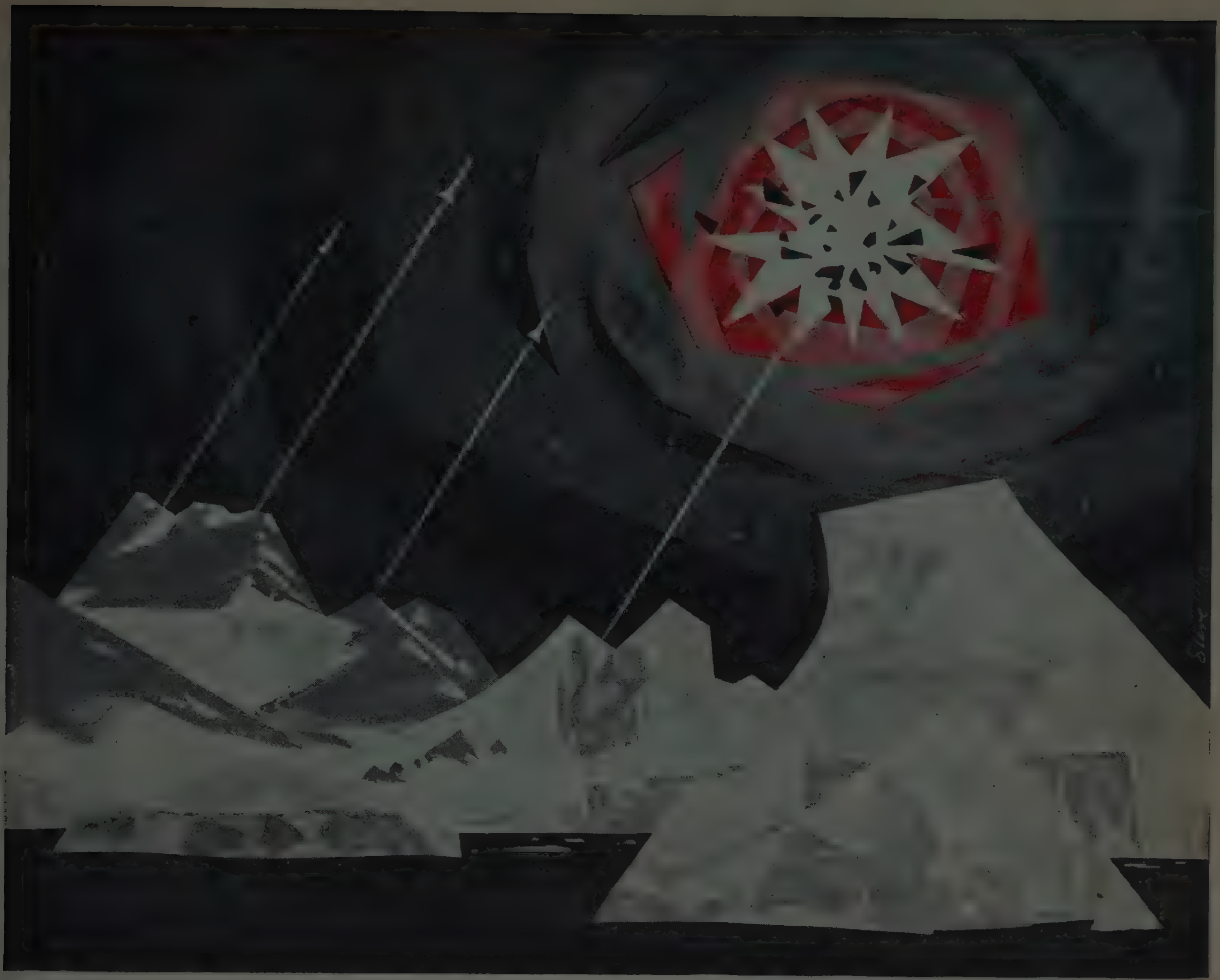

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To integrate and control this assault requires accessibility and handling of a staggering volume of data. In the missile era, present methods of gathering and processing data will be inadequate. SAC is automating the system.

As systems manager, International Electric Corporation is developing and will turn over to SAC a world-wide electronic combat control system, an integrated complex of electronic subsystems. The system, employing digital techniques and equipment, will transmit, process and display information on a global basis . . . with only seconds involved.

Engineers whose interests lie in systems engineering, data processing and communications will find in this long-term project exceptional opportunity to exercise creative competence and individual initiative. For details of engineering assignments write B. J. Crawford, Director of Technical Staffing.

INTERNATIONAL ELECTRIC CORPORATION
An Associate of International Telephone and Telegraph Corporation
Route 17 & Garden State Parkway, Paramus, New Jersey

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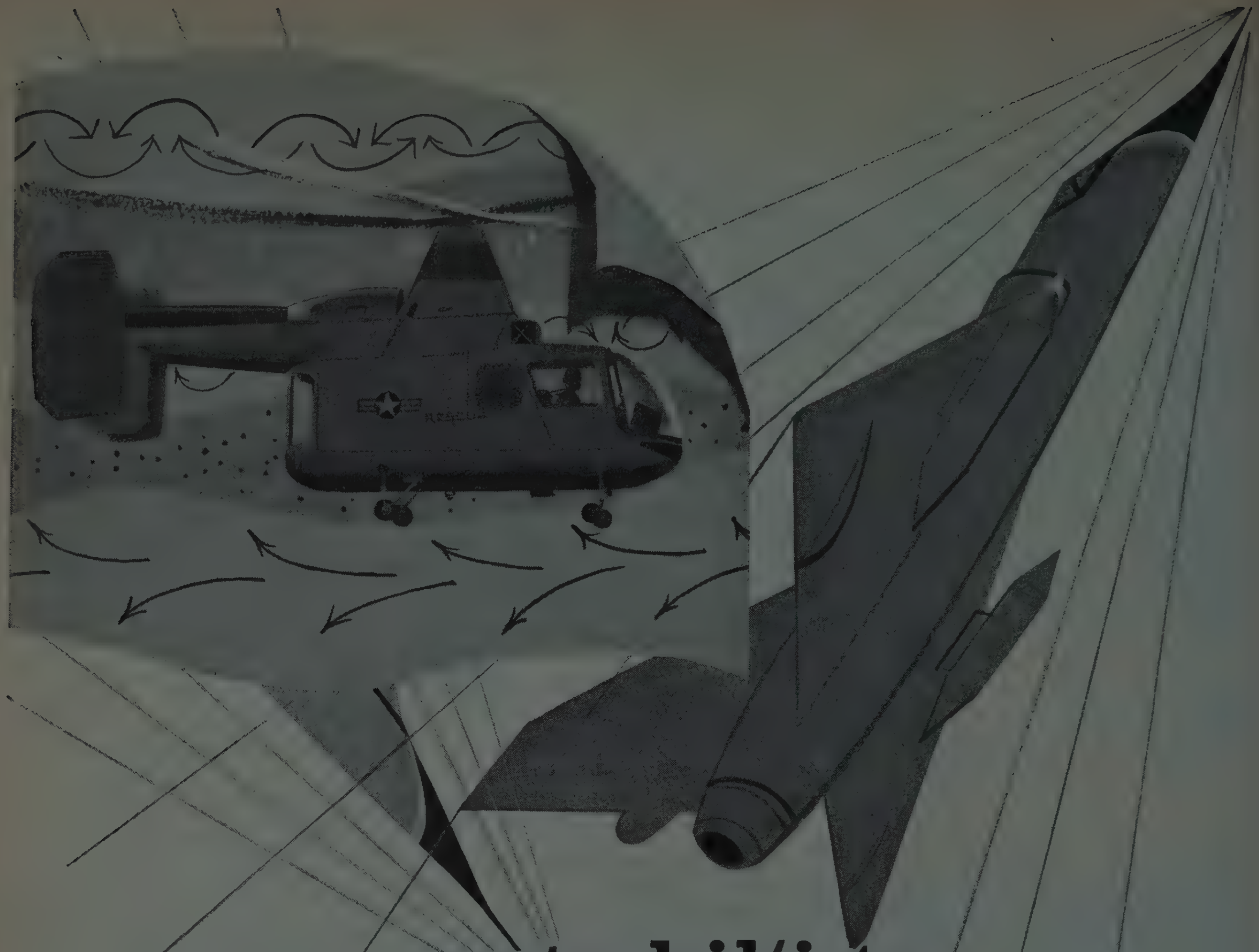

sta-bil'i-ty

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Bloomfield, Conn. — Air Force established new world record by flying Kaman H43-B turbine helicopter to 30,100 ft.

World's Record #2

Edwards AFB, Calif. — Air Force established new world record by flying Convair F-106 over an 18 km course twice, averaging 1,525.9 mph.

Stability augmentation from American-Standard steadies both of these record-setting vehicles. And in missiles — the Navy Terrier and Tartar; and submarines — the Polaris class, American-Standard, Military Products Division supplies gyros fundamental to accurate positioning and control.*

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AMERICAN-Standard

MILITARY PRODUCTS DIVISION

Positions Open

(Continued from page 384A)

uate programs in engineering, developing undergraduate and later graduate programs in sciences, constructing new science and engineering building to prepare engineers for the industrial and technical development of Turkey and the Middle East. Address inquiries to Dean Howard P. Hall, School of Engineering, or Prof. Frank Potts, Acting Dean, School of Sciences, Robert College, Bebek, Post Box 8, Istanbul, Turkey, with copy to Near East College Assoc., 40 Worth St., Room 521, New York 13, N. Y.

ENGINEERING EDITOR

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Expanding, recently organized dept. with a modern science-oriented curriculum, seeks a well-qualified person who is interested primarily in teaching. Advanced degree required. This is an unusually attractive position for the right individual. 12 month salary assured, if desired for approximately 10½ months service. Possible to have every other summer off while earning full salary. Salary range is approximately $6,000 to $8,000. Private, medium-sized university in midwest. Send complete resume to Box 2011.

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Expansion of graduate work in E.E. at Syracuse University has created several opening at the Assistant and Associate Professorial ranks. Except in very unusual circumstances, applicants should have a Doctorate in E.E. or a closely allied field. Opportunities exist for combination of teaching and research during the academic year, and for summer employment on research. Teaching is primarily at the graduate level. Salary depends on experience, but in most cases the yearly salary (for 11 months work) is reasonably competitive with industry. Write to Dr. W. R. LePage, Chairman, Dept. of E.E., Syracuse University, Syracuse 10, New York.

ASSOCIATE OR ASSISTANT PROFESSOR

Expert in field of semiconductors. Ph.D. is minimum requirement, applicant must have some teaching experience. Academic rank and salary dependent on demonstrated ability and over-all experience. The man in this position will divide his time between teaching and research. Appointment begins Sept. 1960. Write, including resume to W. R. Beam, Head, E.E. Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

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Scientific book publisher needs radio engineer to plan and develop new books. Publishing experience desirable. Write in detail. State salary. Box 2012.

ENGINEERS

Major firm seeking (1) Section leader, Electromechanical design, (2) Section leader, testing and reliability, knowledge of Military acceptance testing, (3) Manufacturing engineers, knowledge of standards, process and tool engineering for electromechanical display equipment. Top future positions. Benefit programs. Salaries $8,000–$15,000. Contact Mr. W. Hart, Witty-Polon Management Consultants, 176 East 75 St., New York 21, N. Y. Telephone: Lehigh 5-4222.

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Assistant and/or Associate Professor of E. E. with interest and experience in one of the following areas: electromagnetic theory, information theory, digital computer logic and numerical methods, solid state. Ph.D. required, Combination of reasearch, graduate and undergraduate teaching. Address inquiries to Dr. C. Polk, Head Dept. of E.E., University of Rhode Island, Kingston, Rhode Island.

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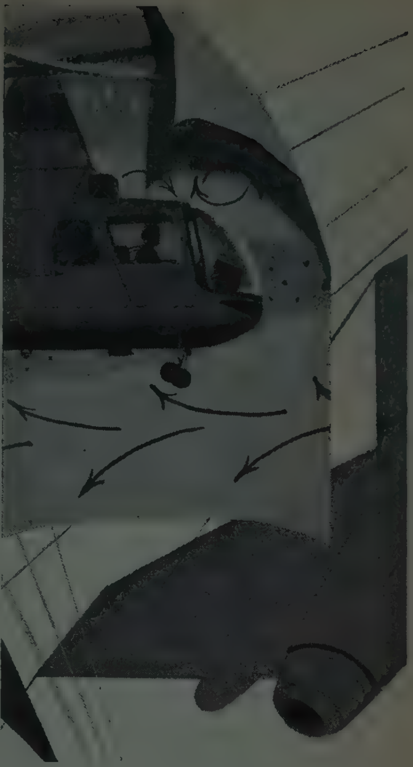

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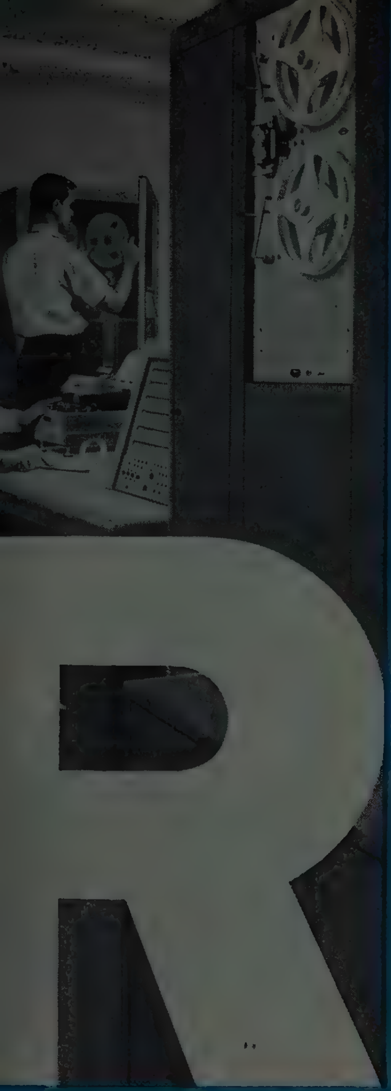

To Members Attending The I.R.E. International Convention

Lockheed Missiles and Space Division has made significant contributions in electronics in such areas as: computer development; telemetry; radar and data links; transducers and instrumentation; antennas and electromagnetic propagation and radiation; ferrite and MASER research; data reduction and analysis; solid state electronics, including photovoltaic devices, electrochemistry, infrared optics; FM-FM data systems; PAM-PCM data links; and logical design.

Special emphasis is being attached to the research, design and development of improved military electronics systems for communications, including new methods of data transmission, reception and storage. Pioneering work is also being conducted in space vehicle borne computers, DC-AC inverters, non-gyro guidance systems. Studies in oceanography include underwater communication and navigation, and natural phenomena and military aspects of the deep sea.

Lockheed's programs reach far into the future and deal with unknown environments. It is a rewarding future and one that outstanding scientists and engineers are invited to share. Members of our scientific staff will be available at the I.R.E. Convention in New York to discuss openings in these and other related fields. You are invited to contact them there, at MUrray Hill 8-7714, or write: Research and Development Staff, Dept. C-33, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

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In order to give a reasonably equal opportunity to all applicants and to avoid overcrowding of the corresponding column, the following rules have been adopted:

The IRE publishes free of charge notices of positions wanted by IRE members who are now in the Service or have received an honorable discharge. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion and the maximum number of insertions is three per year. The IRE necessarily reserves the right to decline any announcement without assignment of reason.

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Group Leader: Instrument development for product improvement; development of unique applications of sound, light and electronics to measurement of various process parameters; and development of automatic equipment. 13 years experience; BS. Eng. Physics, MS. Electrical Engineering. Box 2045 W.

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16 years experience in radar, control, and computers. Last 5 years manager of computer design. Prominent through extensive publications and significant patent in digital computer systems. Advanced degree in E.E. Sigma Xi, Senior Member IRE. Seeking increased responsibility. Under 40, married. Box 2046 W.

TECHNICAL WRITER

4 years handbook experience in digital computers, missiles, data processing; 2 years in field service. Desires position in Western Europe. Age 34, married. BA.; secret clearance; 4 languages. Box 2047 W.

ADMINISTRATIVE ENGINEER

Engaged in project administration in connection with R&D activities. Experience involved multi-million dollar subcontract contractual and technical administration and development of administrative operating and control procedures. BBa., MBA. 9 years diversified engineering. Engineering includes test equipment designs and systems engineering. Schooled in military electronics. Desires responsible administrative position with a growing future. Box 2048 W.

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Age 43; broad electronic experience with vacuum tube and transistor circuitry, analog computers, gyro systems, power supplies, miniaturization and printed circuitry. Senior Member IRE. Tau Beta Pi, Eta Kappa Nu. Will relocate for an outstanding opportunity. Box 2051 W.

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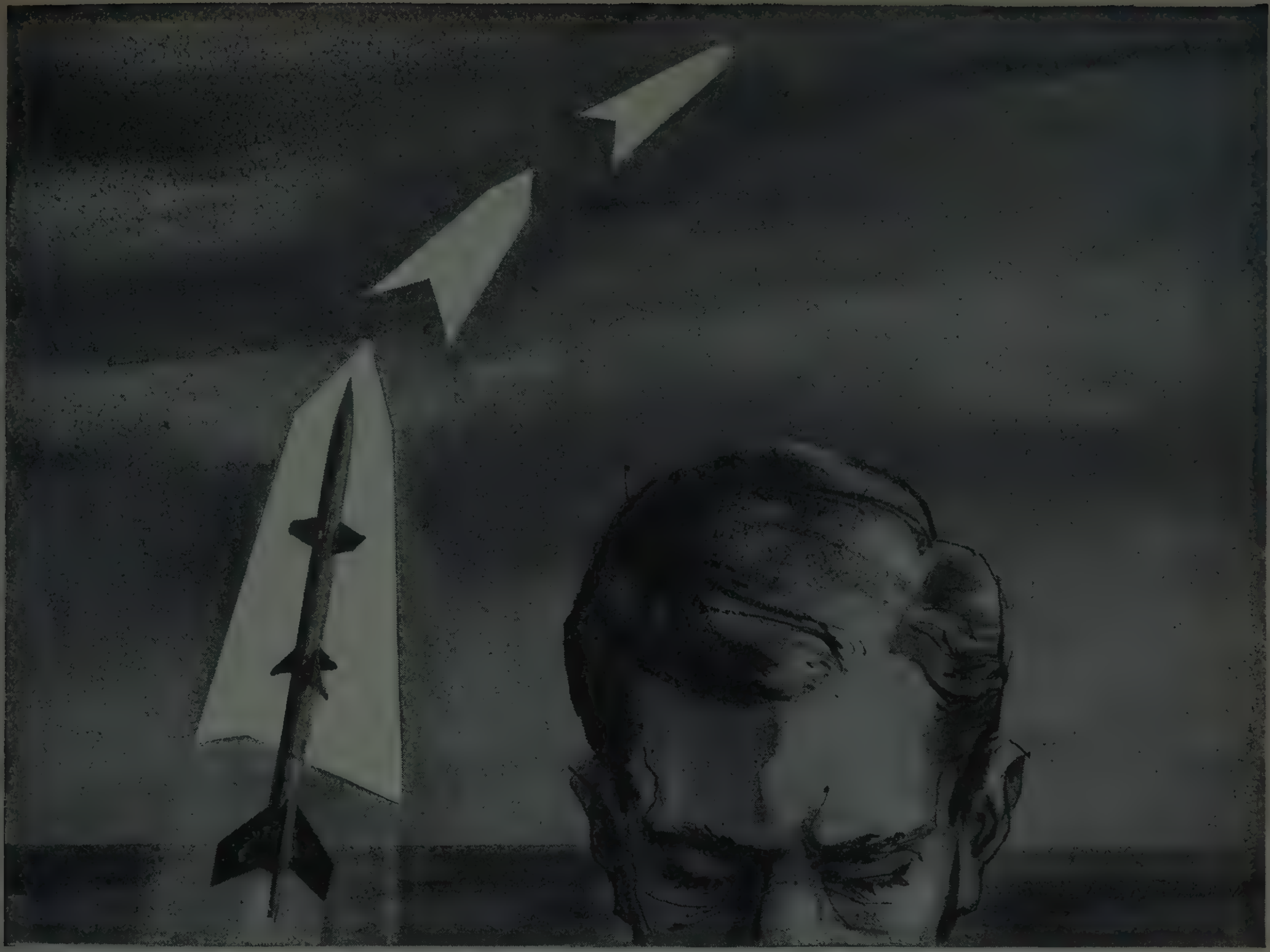
BEE., MEE. Had project responsibility in audio, video computer circuits and equipment; conscientious supervisor. Desires managerial responsibility and substantial challenge. Box 2058 W.

ELECTRONICS ENGINEER

BEE. 1952. MEE. 1955. Age 31. Desires Project Engineering or managerial position with growth potential. 4 years experience, to Project Engineer level, designing and developing large

(Continued on page 392A)



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8603 Georgia Avenue, Silver Spring, Maryland

2 SENIOR SCIENTISTS

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Immediate opening for a Special Assistant to the Director of Melpar's Advanced Development Staff, located in Falls Church, Virginia. Responsible for undertaking independent research assignments and coordinating with other groups in formulating new techniques, devices, and systems. Applicants should have Ph.D in physics, plus five to 10 years' experience in such fields as acoustics, IR, and optics. Particular strength in electromagnetic wave theory is highly desirable.

2. INFORMATION THEORY SPECIALIST

Melpar's Applied Science Division—located in the Boston area—is now conducting basic research programs and studies of phase-coherent, anti-multipath correlation systems, matched filters, ambiguity analysis, waveform analysis, and signal coding. Melpar's Applied Science Division facilitates and encourages independent research. Applicants should have MS or Ph.D. degree, with competence in statistical theories of communications, information theory, or decision theory, with experience in basic or applied research in communications theory, artificial intelligence, and pattern recognition.

For personal interview during IRE Convention

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Melpar Suite—Waldorf-Astoria Hotel

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Positions Wanted

By Armed Forces Veterans

(Continued from page 390A)

radar systems. Some teaching and research experience. Former Signal Corps officer. Licensed Professional Engineer in New York. Box 2059 W.

ENGINEER

Desires position not wholly technical involving possible overseas travel. LTJG USNR. Tau Beta Pi, Eta Kappa Nu. Unmarried. BS. and MS. in E.E. from large midwestern universities. Box 2060 W.

ELECTRONIC ENGINEER

BS. 1956; MS. 1957 in E.E., Stanford University. Experience 6 months digital circuitry design, 2½ years in trajectory computation and guidance analysis including some programming for large digital computer for USAF. Attended special USAF course in Ballistic Missile Fundamentals. Desires position in missile or computer R & D with opportunity for responsibility. 1st Lt., Age 25, married. Available July 1960. Box 2064 W.

ELECTRONIC ENGINEER

BE. and MS. in E.E. (electronic option) from USC. Phi Kappa Phi, Tau Beta Pi, Eta Kappa Nu. Available July 1960 upon completion 5 years commissioned service with Navy (Lt.). Experience in shipboard electronics, teaching at Naval Academy. Interested in instrumentation, computer application. Southern Calif. area desired (possibly future in Latin America). Age 28, married. Resume upon request. Box 2065 W.

ELECTRICAL ENGINEER

Signal Officer, USASRDL, BS. in E.E. Age 23. 2½ years experience in tube research, development and manufacture (cathode-ray and microwave). 3 first prizes (IRE and AIEE) for technical writing and presentation. Desires position leading toward management responsibilities. Married. Available March 1960. Box 2066 W.

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BSEE. 1948. Heavy experience in industry controls and allied fields. Desires managerial position with strong and growing company in the field of industrial electronics. Location anywhere. Box 2067 W.

ELECTRONIC ENGINEER

BSEE. 1957. 1/Lt. USAF. Electronic instructor while on active duty. Some graduate work completed. Desires an R & D position in the mid-Atlantic area. Age 24, married, 1 child. Box 2068 W.

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Experienced sales and engineering background in electronics to distributors, OEM and direct customers. Age 38 with excellent sales record in product and components. Experienced in sales promotion. Desires position with responsibility and future. Box 2069 W.

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Desires position as Sales Engineer in southeastern U.S. Over 9 years experience in elec-

(Continued on page 394A)

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Positions Wanted

By Armed Forces Veterans

(Continued from page 392A)

tronic engineering, broadcasting, liaison and manufacturing with strong desire to enter sales. 2 years toward BSEE. and 2 years accredited technical school. Box 2071 W.

ENGINEER

Ph.D., June 1960, 5 years industrial experience, several semesters experience teaching lecture courses at the senior EE level. Interested in teaching and research at progressive EE dept. Prefer western U.S. Box 2049 W.

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3 years engineering experience in digital and analog system development. 2 years technician experience in switching. 4 years USAF Nuclear Weapons. Interested in system engineering, especially hybrid systems for control and data processing. Tau Beta Pi, Eta Kappa Nu. Available on completion of M.E.E. requirements, June 1960. Age 28, married, 2 children. Box 2050 W.

Whom and What to See at the Radio Engineering Show

(Continued from page 380A)

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Geosciences & Instrumentation Division
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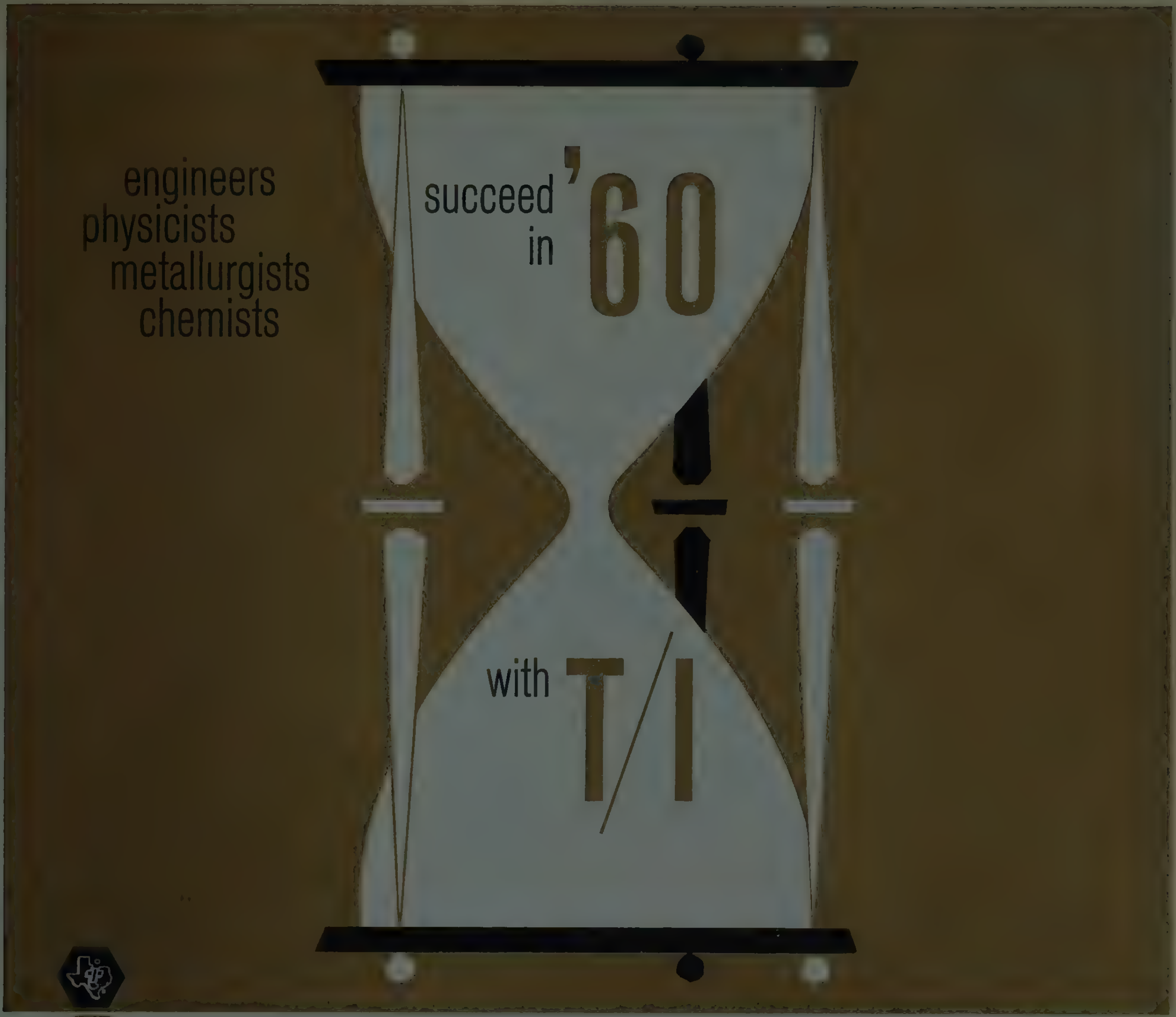
(Continued on page 397A)



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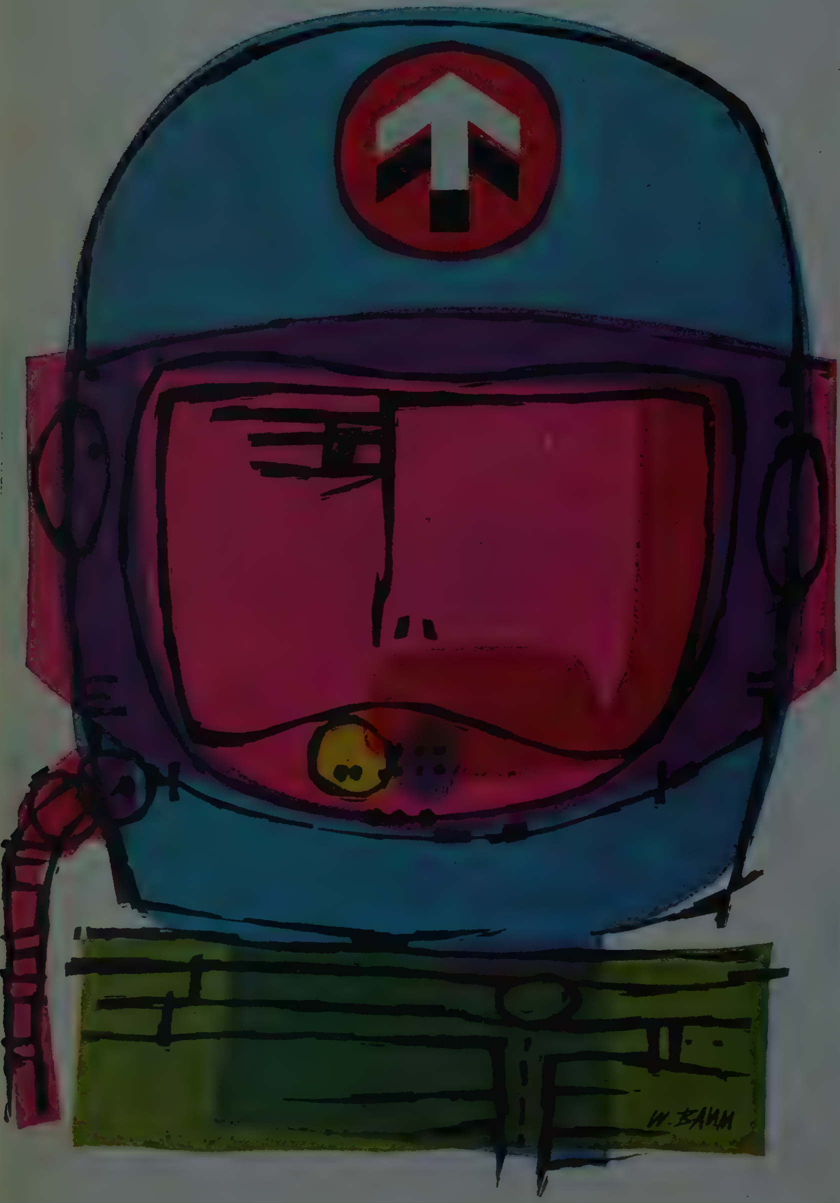

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Whom and What to See at the Radio Engineering Show

(Continued from page 394A)

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(Continued on page 398A)

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Whom and What to See at the Radio Engineering Show

(Continued from page 397A)

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(Los Angeles), Calif. and
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Booths 1431-1631

Thompson Ramo Wooldridge Inc.: Charles Wacker; DAGE Television Division: O. D. Page, S. T. Spangler, D. A. Schonmeyer; Ramo-Wooldridge Division: Gary Langseth, Milton Baldridge, Ross Penny, Ken Busche, Harold Luxenberg, Denny Pidhayny, Lawrence Murdock, Roger Trapp, Richard Nishimura; TAPCO Group: F. G. Weihmiller, J. N. McCarthy, R. T. Meyers, W. W. Welsh, P. A. Trostel, W. H. Baucom, C. W. Chase, T. B. Ray, C. W. Sargent; Thompson-Ramo-Wooldridge Products Co.: Ken Hayes, James Carolan, Bertram Newman, Henry Bechard, Lewis Ward, F. Lee Johnson, Dan L. McGurk

Analysis Console

Closed Circuit Television Systems; Command Destruct Receiver; *Telemetry Calibrator; *Analysis Console (above); Special Purpose Antennas; Microwave Delay Lines; *Multiphase Unbalance Protective Device; *Very High Power Silicon Transistors and Diodes; *Video Telemetry Transmitter; *Static Inverter; *Space Capsule Amplifiers; *Analog Computer Elements; Waveguide and Coaxial Switches; Speed Controls; Antenna Coupler; RW-300 Digital Control Computer; *RW-300 Magnetic Tape Unit. See also: Pacific Semiconductors, Inc., Booths 2742-2744

Three Point One Four Corp.

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Yonkers, N.Y.
Booth 1121

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(Continued on page 400A)

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Other manufacturers will duplicate our currently unique transistors. By then, our projects now in Research & Development will have become the advanced products of their own time and the challenge continues. Success is followed by greater successes ... or obsolescence.

Our facilities and working atmosphere have attracted engineers and scientists of the highest caliber. Their work, combined with creatively oriented management policies and the abilities of the entire staff, has resulted in a whole series of product innovations.

We are still moving on in transistors, and have now branched into diodes of similarly advanced technologies. Current programs include integrated solid-state circuitry and investigations of semiconductor films and III-V compounds. If yours is a relevant background, and if you would like to move ahead with us, we would very much like to hear from you.

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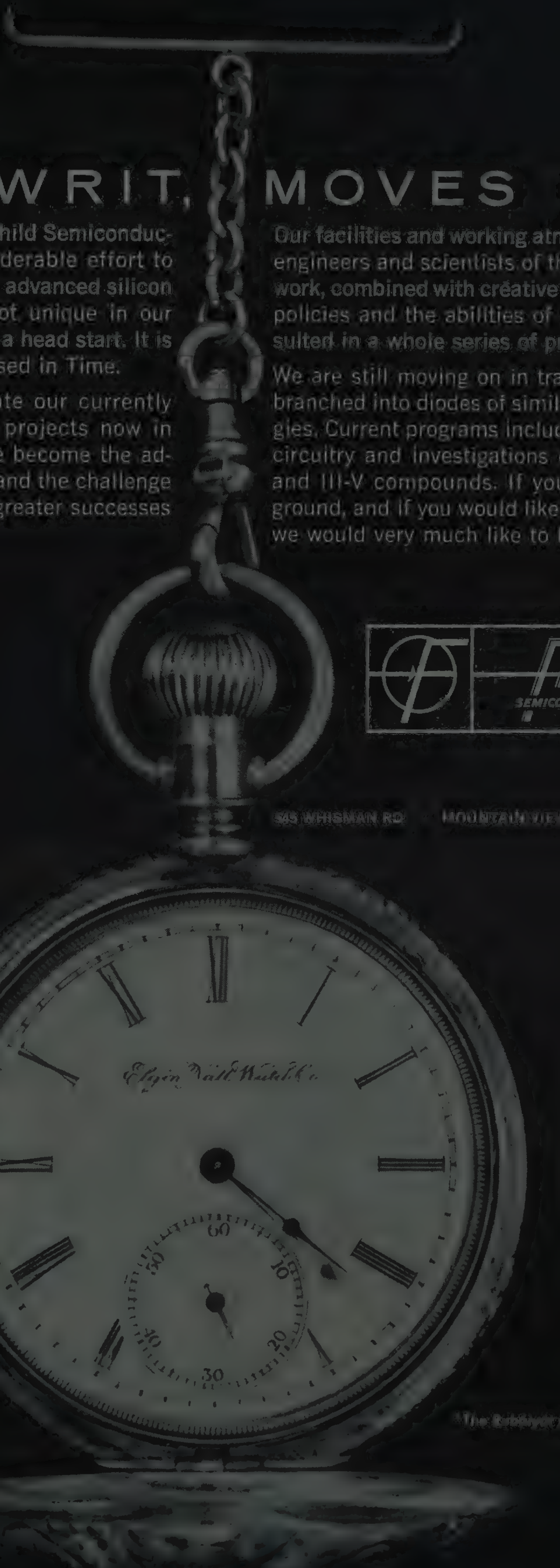

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Avco/Crosley

Whom and What to See at the Radio Engineering Show

(Continued from page 398A)

Times Facsimile Corp., Booths 1610-1618, 1709-1717
See: Litton Industries, Inc.

Tinnerman Products, Inc., Booths 4207-4211
P.O. Box 6688
Cleveland 1, Ohio

R. C. Overstreet, L. H. Flora, E. E. Griger, R. J. Holton, Wm. M. Buttriss, W. H. Gibbons, F. E. List, R. H. Hansen, D. M. Hager, H. C. Bodine, T. M. Landfear, W. F. Brophy

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Toko Radio Coil Laboratories, Booth 2935
See: Japan Electric Industry

Tokyo Shibaura Electric Co., Ltd., Booth 2935
See: Japan Electric Industry

Topp Industries, Inc., Booths 2713-2715
See: U.S. Semiconductor Products, Inc.

CAFETERIA
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Torrington Manufacturing Co., Booth 1919
Torrington, Conn.

Adam Wilczenski, George Merrow, Henry Foeller, Frank Hohmeister

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Booth 1617

L. H. Tokarczyk, E. H. Moore, ▲ M. M. Lasensky

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Transicoil Division, Daystrom, Incorporated, Booth 1805
Montgomery County
Worcester, Pa.

John Gattoline, Robert Rochow, Warren Carnel, C. William Donnelly, Cliff Conkling, William Schmitz, Russell Kerr, Thomas Corbett, William Hargreaves, D. W. Bloser, Frank Hagen, Carmine D'Amico, Peter Yeannakis, Samuel Lapidge, Joseph Roberti, Vincent Roberti

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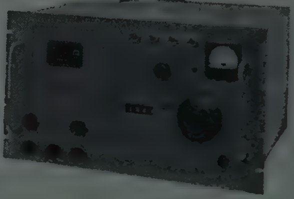
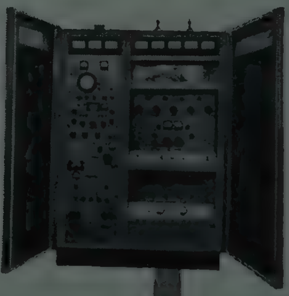
(Continued on page 402A)





GPR-90
Bulletin
179

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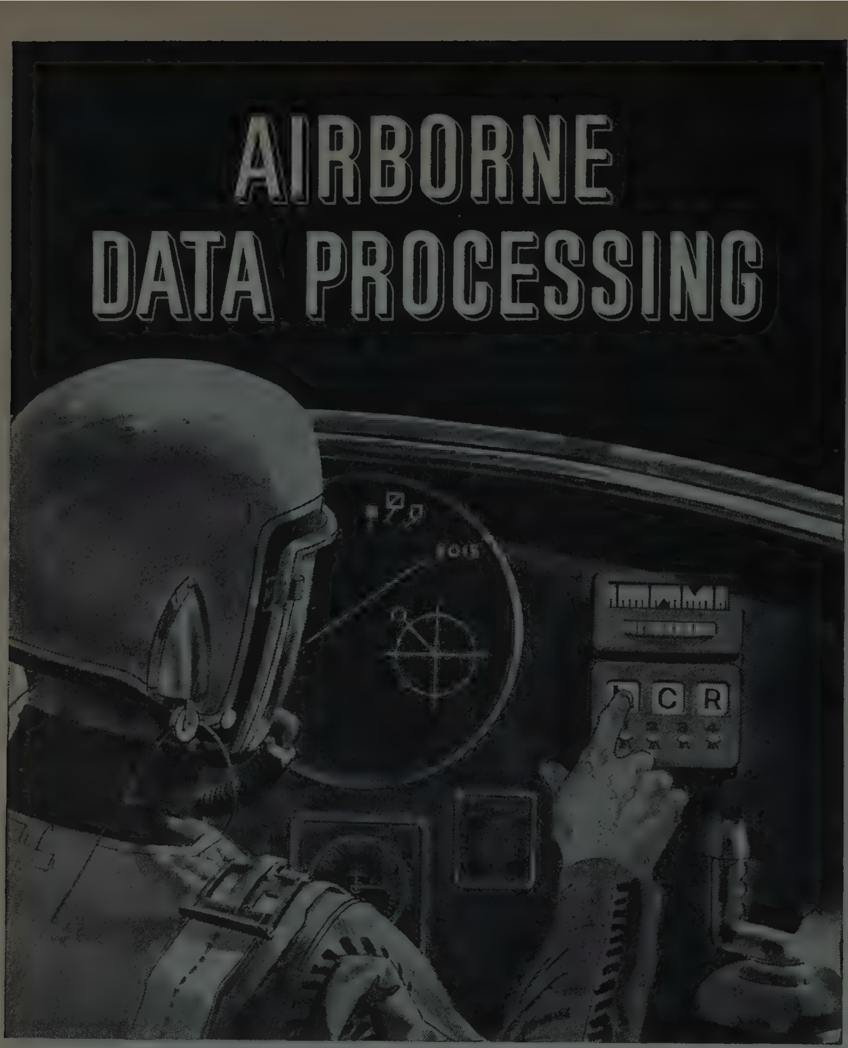
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The Bendix Systems Division program in Data Processing offers unique opportunities for engineers to apply advanced techniques in the design and implementation of complex data processing systems. Current areas include:

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Bendix Systems Division
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AVIATION CORPORATION

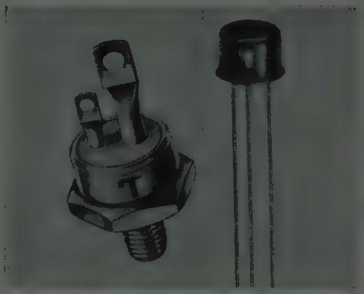
Whom and What to See at the Radio Engineering Show

(Continued from page 400A)

Transitron Electronic Corp.

168 Albion St.
Wakefield, Mass.
Booths 1319-1323

H. Thomas Neavitt, Lawrence W. King, ▲ William Slusner, ▲ Nick De Wolf, Charles Hill, Peter Jenner, Thomas Clark



Silicon Controlled Rectifier (Left)
The Transwitch, Transistor Package (Right)

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Travco Associates, Booths 1230-1232

45 N. Station Plaza
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T. Greenburg, S. Benerofe, J. Duncan, J. Traise, M. Lindgren, R. Traise

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Triad Transformer Corp., Booths 1610-1618, 1709-1717

See: Litton Industries, Inc.

Trio Laboratories, Inc.

DuPont Dr.
Plainview, L.I., N.Y.
Booth 3033

▲ Jay S. Salz, Jurgen Worthing, Philip Greenstein, John R. Crawford, Harold D. Miller

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(Continued on page 404A)

▲ Indicates IRE member.
* Indicates new product.

UNUSUAL ENGINEERING SUCCESS can be achieved in the creative climate at Martin Orlando. Talented young engineers and scientists carry big assignments in challenging electronics and missile programs. New projects and an expanding engineering department present rewarding opportunities to men who can manage and staff important new assignments.

WORK WHERE YOU WANT TO LIVE Engineers have discovered the fun of fishing, water skiing, boating, and swimming in the 54 lakes inside Orlando's city limits. They cook out more, spend more time with their families out-of-doors, and play more golf every month of the year than ever before.

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IRE TALK WITH ELECTRONICS MANAGERS AT THE WALDORF-ASTORIA, MARCH 21-24

The widely varied capabilities of Space Electronics Corporation, a vital, expanding organization, have contributed to significant and practical developments for the nation's missile and space programs.

The fly's eye is nature's version of a multi-dimensional scanner. A current project at Space Electronics is the development of an advanced technique, comparable with that found in the fly's eye . . . a pattern recognition and data processing system known as ——

[illegible]

Challenging career opportunities, offering immediate responsibility, are open to qualified engineers and scientists. Inquiries should be directed to the attention of Dr. James Fletcher, President of Space Electronics Corporation.

SPACE ELECTRONICS CORPORATION

930 Air Way Glendale 1, California CHapman 5-7651

Whom and What to See at the Radio Engineering Show

(Continued from page 402A)

Triplett Electrical Instrument Co.
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Bluffton, Ohio
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Norman Triplett, Ropp Triplett, Morris Triplett, Arthur Daschke, George Salmons

New 2590 Transistor Tester

Electrical measuring indicating instruments (Panel and Portable Types), instrument relays, complete line of test equipment for electronic, electrical, radio and television. Also special industrial, electrical and electronic test equipment and instruments.

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Booth 2305

▲ Mel M. Jones, John H. Kinnaw

Power Type Wire Wound Resistors and Rheostats, Both Commercial and Military Approved.

(Continued on page 410A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

Will tomorrow be a challenge ...or a bore?

If you feel that your present job is not fully tapping your potential, here are 4 new career opportunities for Electronics Engineers that have every bit of the challenge you may be looking for . . .

---

1 *Site Systems Reliability Engineer:* This position calls for a seasoned engineer capable of integrating and directing on-site reliability assurance activities necessary to secure customer acceptance of the detection system. Unusual combination of technical ability, relations and communications (written and spoken) is required. Desirable experience includes approximately ten years in design and field installation of transmitters on electronic systems with ability in both electronic and mechanical fields. Ability to motivate technicians for optimum performance is necessary. Salary structure is equal to the challenge.

---

2 *Radar Equipment Systems Specialist:* This position calls for a creative engineer capable of conceiving and directing the design of long-range radar systems. Desirable experience includes around ten years in at least one of the following: radar systems design, antenna systems, R.F. components, radar receiver systems or radar data processing systems. Salary structure is equal to the challenge.

---

3 *Advanced Systems Engineer:* This position calls for a creative engineer capable of defining future defense and space detection problems as well as the ability to conceive and establish the feasibility of optimum systems solutions to these problems—making use of the most advanced techniques and understanding. He must recognize the need for and coordinate the development of new techniques and the exploration of new phenomena in the area of detection systems. Background desired: Bachelor degree plus a combination of advanced training and several years experience in both the theoretical and practical aspects of detection systems engineering. A desire to work in the conceptual phase of system design with the analytical ability required to evaluate and demonstrate the effectiveness of proposed systems.

---

4 *Advanced Radar Systems Analysis and Development Engineer:* Engineers are needed who are able to visualize and define future defense and space problems—conceive advanced radar systems to solve them. An advanced degree and/or strong background in system analysis and design is essential. Assignments open include: analyze and define requirements for advance detection systems and determine broader parameters for such systems, establish their feasibility; analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery. 228-9

All of these openings are on General Electric missile and satellite detection projects and will be filled with engineers having the capability and desire to make creative contributions.

Write in confidence to T. M. George,
Supervisor—Personnel Administration

Missile Detection Systems Section
HEAVY MILITARY ELECTRONICS DEPARTMENT
GENERAL ELECTRIC
SYRACUSE, NEW YORK

machine's decision-space

working

The final launching decision for future space vehicles will probably be made by electronic logic devices—far faster, far more precise and far more reliable for this purpose than the human brain. Resistor-transistor circuit modules are the basic elements of the "decision machine."

Such devices are the pre-launch test units developed by Honeywell's Aeronautical Division for validating its stabilization control systems. They check the orientation systems in a space vehicle; a simple GO or NO GO signal diagnoses malfunctions and identifies the offending systems.

The pre-launch checker is another example of the Aeronautical Division's interest in controls. Other developments include adaptive flight control systems, electrically suspended gyros and environmental control systems for space vehicles.

Honeywell has made contributions to Scout, Sergeant, Thor, Atlas, Titan, Mercury, F-104, B-58, X-15, WS117L, Polaris and many others. Current expansion has created openings for senior and junior engineers and scientists in these and similar programs. Your inquiry will get prompt and confidential attention.

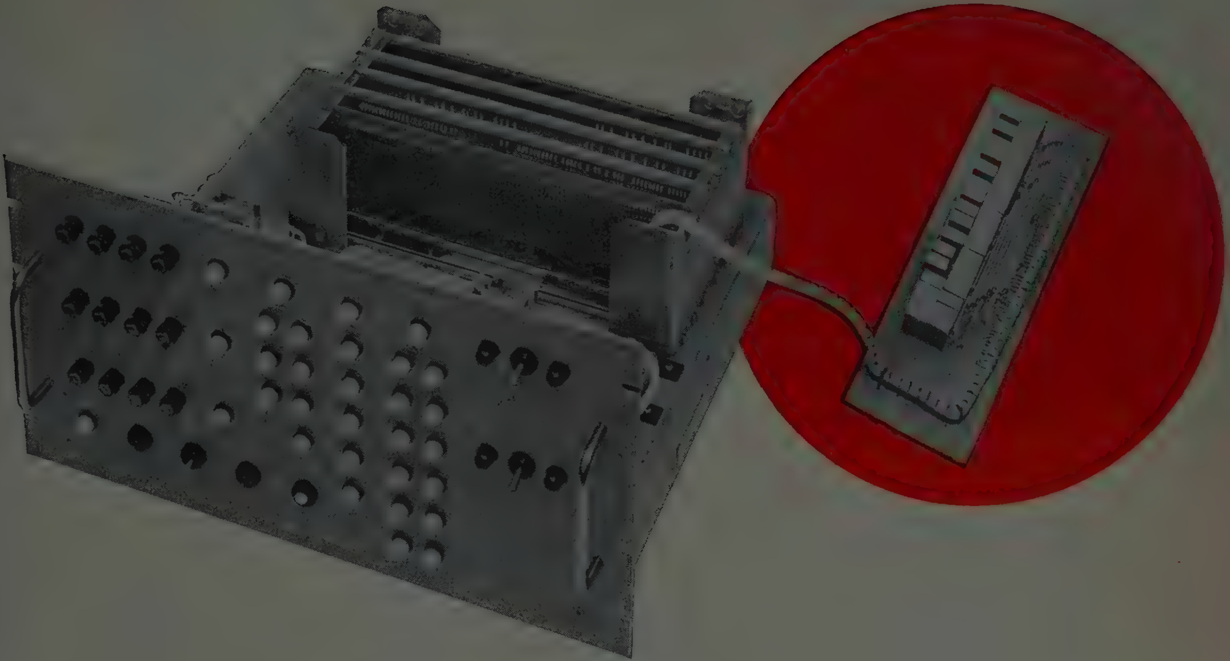
---

man's decision-place

living

Honeywell engineers make their own decisions on where to live—in the city, the country or the suburbs. Most live in or near the Twin Cities—an area where work is typically 20 minutes from home, where nearly every yard is big enough for outdoor entertaining. People here are sports minded, and there are participant and spectator activities to appeal to all.

Minnesota is characterized by the kind of living which is both enjoyable and healthful. Minnesotans are proud of the fact that they have consistently had the smallest ratio of rejections for the Armed Forces Qualification Test.



The Twin Cities is a cultural and educational center. It's the home of the Minneapolis Symphony Orchestra. Its Walker Art Center and Minneapolis Institute of Art are famous for their collections, their progressiveness, their encouragement of young artists. Public school systems in the Twin Cities are nationally recognized for their excellence. There are six colleges located here, including the University of Minnesota, which is just two miles from Honeywell Aeronautical.

Honeywell engineers find these are important parts of the good life they enjoy in Minnesota.

For further information on working at Honeywell Aero—and living in Minneapolis, please send a resume to Bruce D. Wood, Dept. 470A.

Honeywell

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SYSTEM ANALYSIS

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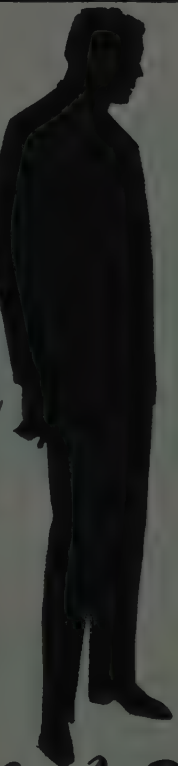

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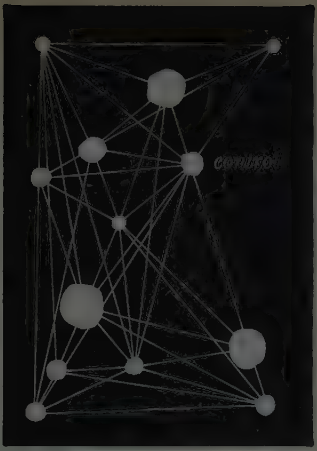

professional opportunities at Honeywell Aero

INERTIAL SYSTEM DEVELOPMENT

Systems Analyst—employs mathematical techniques such as operational calculus, matrix algebra, and difference equations to the solution of problems concerning performance characteristics of various system configurations including analysis for error introduced by sensors and computer, requirements for alignment, and optimization of the system configuration.

Digital System and Logic Designer—requires familiarity with capabilities of various digital computer configurations and ability to employ system and logic relations in specifying necessary configuration for solving inertial navigation problem.

Electronic and Mechanical Designers—engineers with background in transistor circuitry, inertial sensor development and evaluation, and precision mechanical equipment design are needed to perform component development and evaluation, and to design mounting and alignment equipment.

APPLIED RESEARCH

Programmer Analyst—mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

Human Factors Engineer—capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

Systems Analyst—capable of conducting research studies involving new techniques of space navigation and guidance.

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Flight Control Systems—analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering—through design, testing, and proof of electrical and mechanical equipment—including flight test and production test.

Advanced Gyro Design—Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

Electronic Circuit Designers—experienced in the areas of analog/digital computers, transistor circuits, servos, instrumentation, and/or gyro stabilization.

For the less experienced professional engineer, there are opportunities in the Evaluation Laboratory which lead to careers in any of the above fields.

To investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Bruce Wood, Dept. 470B

To explore professional opportunities in other Honeywell operations coast to coast, send your application to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

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AERONAUTICAL DIVISION
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SENIOR MICROWAVE ENGINEER

You will be given system responsibility for the development of new concepts in the generation, propagation and radiation of microwave power for heating, cooking and curing purposes, in numerous commercial and industrial applications. (Raytheon is one of the few electronics companies whose staff includes systems, advanced development, and design engineers in these fields).

You must have a BSEE or equivalent and should have 8 years of broad design or advanced development experience in the microwave field in order to handle the planned assignments. (Experience in radar development, for instance, or DC power generators or magnetrons.) Since we're looking for an exceptional individual—who will be rewarded accordingly—the deciding factor will probably be your creativeness and ingenuity, as evidenced by: patent disclosures; significant publications; or descriptions of accomplishments not formalized by patents or publication.

MICROWAVE LICENSEE ENGINEER

You will serve as liaison between Raytheon and licensees, assisting in the design of microwave cooking units for these licensees' commercial ovens. This will involve working with the licensees' design engineers to solve such problems as heat, sanitary considerations, microwave distribution, wave modulation, insulation and cost reduction. You will also help translate licensees' suggestions into product improvements.

You should be a senior-level electronics engineer with a BSEE or equivalent and should have 5 years' applicable experience. Background in design of test equipment, high-power modulators, or commercial microwave equipment is especially useful, as is knowledge of magnetrons, underwriters' requirements and FCC regulations. Basically, we're looking for a top design and sales engineer (travel will be limited, however) so salary is commensurate—that is, excellent.

Both positions are in the suburban Boston area and offer attractive cultural, educational and recreational opportunities. Relocation assistance is available. Please phone collect (BIgelow 4-7500) or forward your detailed resume to Mr. Paul R. Alexander, Manager of Professional Personnel, Commercial Apparatus & Systems Division, Raytheon Company, Watertown, Massachusetts.

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University of New Mexico, Albuquerque

Whom and What to See at the Radio Engineering Show

(Continued from page 404A)

Tung-Sol Electric, Inc.
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Newark 4, N.J.
Booths 2428-2430, 2521-2523

Gene Cacavio, James Davenport, William Dickey, Herbert Evander, R. W. Logan, Walter Miller, David Sanger, C. A. Thumm, Fred Warren, Robert Zimmerman

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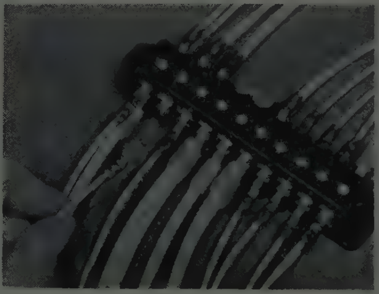
Booth 1824

Frank A. Kasala, William Bryan, Charles F. Krause, Jr., C. Parke Masterson, Joseph Lavoratta



Twin Lock T-1010 Terminal Block

T-1000 Terminal Block (top-entry). T-1010 Terminal Block (above), side-entry, for general defense industry use; especially designed for flat, crowded spaces where vertical blocks won't fit.

USECO, Inc., Booths 1610-1618, 1709-1717

See: Litton Industries, Inc.

Ucinite Company, Div. United-Carr Fastener Corp., Booth 2536
459 Watertown St.
Newtonville, Mass.

O. H. Bramhall, W. Flanagan, Hector Petri, E. B. Mitchell, R. W. Fraser

Switches, printed circuit connectors and components, test jacks, banana pins, plugs and jacks, vibration isolators, indicator lights, printed circuit switches.

(Continued on page 414A)

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* It's our policy to encourage technical publications. Recent examples are: Bul. of the Amer. Phys. Soc., Vol. IV, pps. 409 and 455 (1959). "Structure and Properties of Thin Films," pps. 298-327, Wiley (1959).

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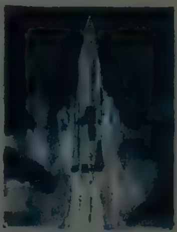

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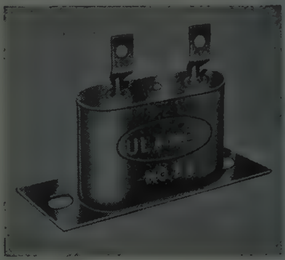
Electron Tube Division
San Carlos, California

Whom and What to See at the Radio Engineering Show

(Continued from page 410A)

George Ulanet Co.
413 Market St.
Newark 5, N.J.
Booth 2119

H. Ulanet, A. W. Burke, George Ulanet, James K. Dennis



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Ungar Electric Tools, Inc., Booth 4135
4101 Redwood Ave.
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Robert Silverstein, William L. Nehrenz, Alvis R. Knowles, R. H. Loehrke, S. Appell, B. Cagan

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Unimax Switch Division, The W. L. Maxson Corp., Booths 1204-1206
Ives Road
Wallingford, Conn.

J. Martinez, J. Jacobs, R. W. Maier

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(Continued on page 416A)

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15

Hughes' FALCON Air-to-Air Missiles in front of Convair F-102A

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Attending the IRE Show, New York, March 21-24? Contact G. P. Lambert at Wellington Hotel for more facts about employment opportunities

MECHANICAL DIVISION

General Mills

Whom and What to See at the Radio Engineering Show

(Continued from page 414A)

Union Carbide Consumer Products Co., Div. Union Carbide Corporation, Booths 2401-2403
30 East 42nd St.
New York 17, N.Y.

C. Anderson, D. B. Ashway, C. P. Barry, W. A. Bruce, R. S. Burgess, ▲D. B. Cameron, A. F. Carey, H. E. Carpenter, S. I. Converse, ▲H. R. Erskine, C. R. Fisher, W. S. Gillette, H. J. Harlow, R. F. Kiefer, F. A. Langell, ▲D. R. Ogden, F. B. Pipal, ▲N. M. Potter, C. J. Sullivan, D. G. Taylor, D. P. Trepte, R. A. Varsha, S. M. Wall

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Union Carbide Corp., Booth 2405
See: Kemet Company

Union Switch & Signal Div., Westinghouse Air Brake Co., Booths 2122-2124
Pittsburgh 18, Pa.

Paul K. Eckhardt, H. J. Myers, K. E. Doriot, A. E. Over, G. A. Dawes, J. W. Hansen, F. E. Baxter

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United-Carr Fastener Corp., Booths 2535-2536
31 Ames St.
Cambridge, Mass.
See: Cinch Mfg. Company and Ucinite Co.

United Catalog Publishers, Inc., Booth 4105
60 Madison Ave.
Hempstead, N.Y.

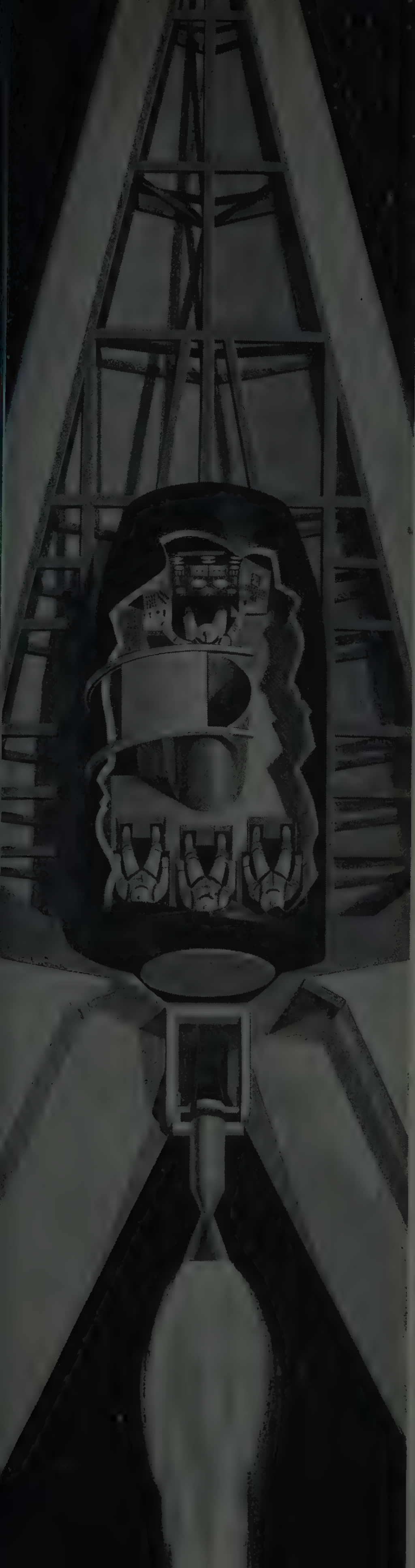
Arthur I. Rabb, Samuel Roth, A. E. Stevens, George Siegel, Harry Birse, George Kerner, ▲Irving J. Frisch, Robert J. Males, Ray Smyth, Curtis E. Glanville, John Mitchell, Harold Gabriel

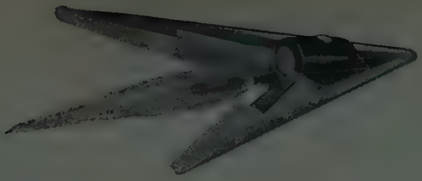
1960 edition—EEM—Electronic Engineers Master. Catalog-Directory of the industry. 1960 edition The Radio-Electronic Master. Catalog of standard products sold by electronic parts distributors. Electronic Products Magazine—the industry's only new product monthly. File-O-Matic, perpetually up-to-date catalog of standard electronic products. Pricing Service—prices of standard electronic products. Audio-File—catalog-pricing service for audio hi-fi products.

United Industrial Corp., Booths 2713-2715
See: U.S. Semiconductor Products, Inc.

(Continued on page 418A)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 21-24, 1960





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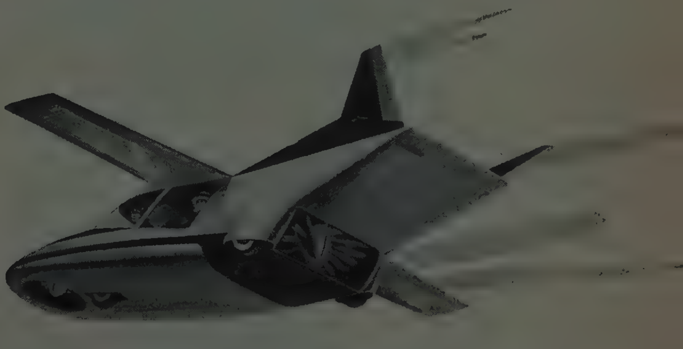

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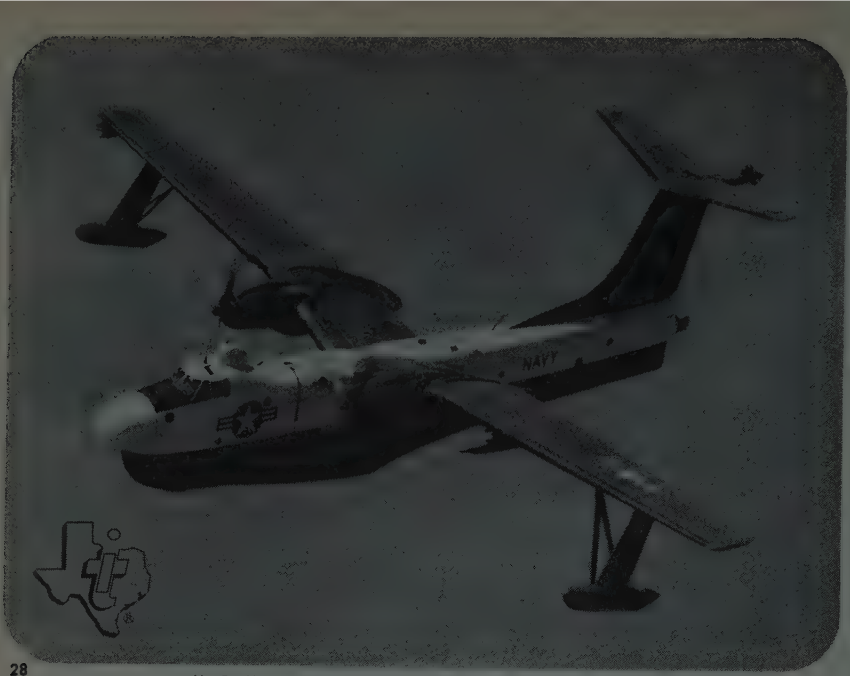
LOCKHEED | CALIFORNIA DIVISION



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Whom and What to See at the Radio Engineering Show

(Continued from page 416A)

United Mineral & Chemical Corp.
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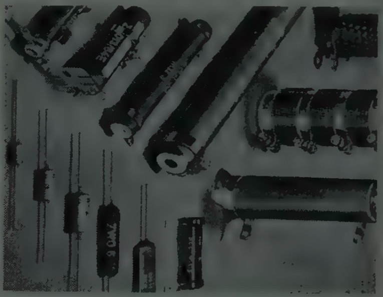
New York 13, N.Y.
Booth 1627B

▲ **Irwin Stelzer, Herbert Rosenthal, Alexander Imich, Terry Koncelik, Ed Wiest, Anita Rosenhan, Manfred DeRewal**



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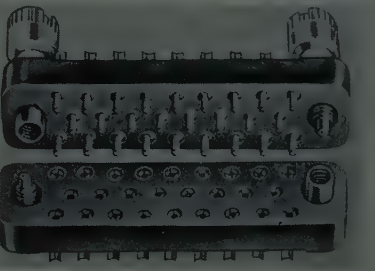
▲ **B. A. Jackson, Henry Nalbantian, Steve Nalbantian, Ernest Klinger, B. R. Remondino**



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U. S. Gasket Co., Booths 2814-2816
See: Garlock Electronic Products

U. S. Semcor, Booths 2713-2715
See: U.S. Semiconductor Products, Inc.

(Continued on page 420A)

▲ Indicates IRE member.
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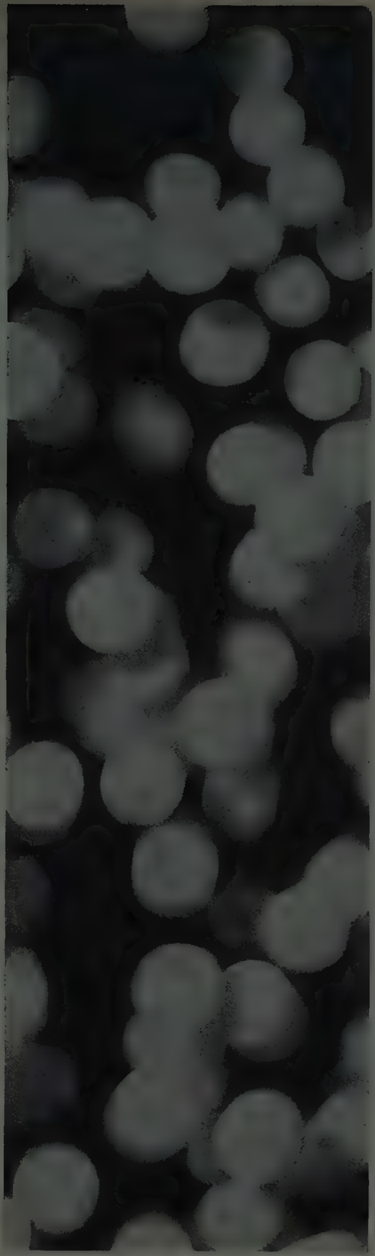

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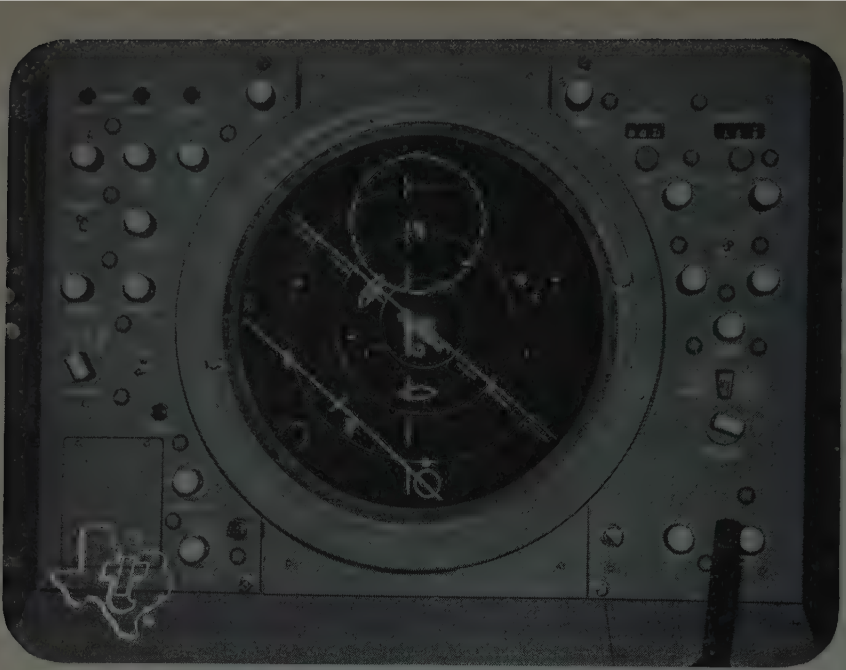

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Whom and What to See at the Radio Engineering Show

(Continued from page 418A)

U.S. Semiconductor Products, Inc.

Div. of United Industrial Corp.
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Booths 2713-2715

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Alite Division
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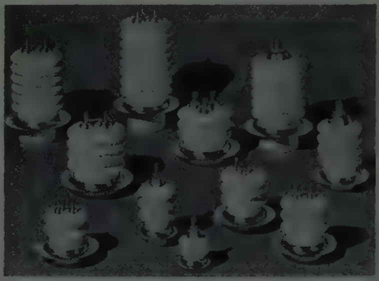
Booths 2205-2207

J. M. W. Chamberlain, Howard Farkas, H. Frahme, W. E. Coykendall, Jr., Walter Perkins, Walter Tarnacki, John F. Schuck



Standard High Voltage Bushings

Alite high temperature, vacuum-tight, high alumina ceramic-to-metal seals. Standard and custom high voltage bushings, feed-through terminals and cable end seals. High amperage network transformer bushings. Alite-to-sapphire seals and components for infrared sensing devices.

United States Time Corporation, Booth 3841
375 Park Ave.
New York 22, N.Y.

H. D. Armstrong, C. D. Stalker, R. J. Zeltner

Wide range Precision Gyroscopes. Broad Aircraft, Missile Gyro background. Volume producer Microsized Gyros. Instruments include Rate Gyros, Floated Integrating Gyros, Accelerometers, and Self-Energized Low Cost Two Axis Gyros. Research and Development Facilities for specialized requirements in Electro-Mechanical Instrumentation.

(Continued on page 422A)

▲ Indicates IRE member.
* Indicates new product.

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

engineers scientists

how can you measure the progress of a company?

Progress doesn't just happen. It's nourished—by research and development. The better the research resources, the greater the progress.

Apply this measuring stick to Collins. Over 25% of Collins personnel are engaged in research and development. Accomplishments include significant advances in Single Sideband, transhorizon and microwave communication systems; space and missile electronics; high speed data transmission; aircraft communication, navigation, instrumentation and control systems. Collins was the first to develop a radio sextant, the first to bounce a radio message off the moon. Collins pioneered the development of airborne SSB equipment, and is currently producing military global communication systems.

Research and development doesn't just happen! It, too, must be nourished—by a constant stream of new ideas from creative engineers and scientists.

And Collins needs additional talented, career-minded engineers and scientists to sustain its rapid growth. You and your creative ideas could fill one of the many positions now open. Each offers unlimited opportunity for growth and advancement in your profession.

Projects are both varied and challenging

Cedar Rapids—E. E.'s and M. E.'s are needed for R & D in airborne communication, flight control, navigation and identification systems, gyro systems, missile and satellite tracking and communication, antenna design, amateur radio and AM broadcast. Basic research opportunities are open for scientists desiring to work in the fields of advanced circuits, solid state, antennas, propagation and advanced systems.

Dallas—E. E.'s and M. E.'s with 2—5 years microwave experience for R & D in microwave systems, radar, ECM, antenna design, solid state switching, and ground support test equipment.

Burbank—Experienced engineers are needed for R & D in high speed data transmission, test equipment design and reliability engineering.

Plan now to talk to a Collins representative at the IRE Show

IRE Show interviews — Collins will be interviewing in New York, Monday, March 21 through Thursday, March 24. For a personal, confidential interview, phone Mr. L. R. Nuss, PLaza 5-4580. A convenient appointment time will be arranged. If unable to interview at this time, send your resume to: Mr. L. R. Nuss, Collins Radio Company, Cedar Rapids, Iowa; Mr. Ben E. Jeffries, Collins Radio Company, 1930 Hi-Line Drive, Dallas 7, Texas; or Mr. F. W. Salyer, Collins Radio Company, 2700 W. Olive Ave., Burbank, California.

COLLINS

COLLINS RADIO COMPANY • CEDAR RAPIDS, IOWA • DALLAS, TEXAS • BURBANK, CALIFORNIA

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Unusual opportunities now open for chemical, electrical, mechanical and metallurgical engineers; physicists and physical chemists (B.S. through Ph.D.) at all levels of experience. U.S. Citizenship not required.

ASSIGNMENTS IN THESE EXCITING FIELDS:

Semiconductor Applied Research—Diffusion and vapor deposition studies; stabilization of semiconductor devices; multijunction switching structures; tunnel diodes in germanium and silicon; surface conditioning problems in germanium, silicon and compounds; silicon carbide studies; energy conversion devices; new semiconductor materials.

Device Design and Process Development—Chemical and metallurgical processes for fabricating germanium and silicon "mesa" type transistors, NPNP switching structures, silicon controlled rectifiers, tunnel diodes and other new devices. Device design and structure analysis.

Semiconductor Mechanical Engineering—Design structures for new transistors. Design and develop: (1) tools for advanced transistor fabrication techniques, (2) crystal growing furnaces, (3) automatic and semi-automatic production equipment, (4) transistor housings.

Computer Analysts—Design large file systems and develop retrieval techniques for application in reliability studies on semiconductor devices. Degree in math or other physical science and a minimum of two years experience in 704 and 709 are required. Background in statistics is desirable but not essential.

OUTSTANDING PERSONAL AND PROFESSIONAL BENEFITS:

- Work with General Electric's world-famous team of scientists and engineers, now making history with dramatic new devices like the tunnel diode and silicon controlled rectifier.
- Enjoy the support of General Electric's ample resources and modern research facilities, in the campus-like atmosphere of Electronics Park.
- Pursue your graduate studies at Syracuse University under G.E.'s Tuition Refund Program.
- Treat your family to gracious living in the heart of New York's Vacationland, adjacent to the famed Finger Lakes Region, Adirondack Mountains and the Thousand Islands. Liberal relocation allowances.

Write in strict confidence
to Mr. M. D. Chilcote, Division K30.

GENERAL ELECTRIC

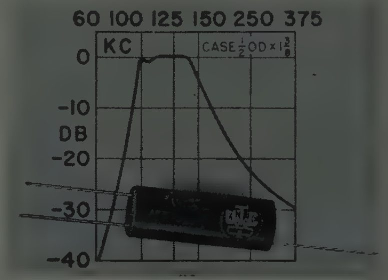
Semiconductor Products Department, Electronics Park, Syracuse, N. Y.

Whom and What to See at the Radio Engineering Show

(Continued from page 420A)

United Transformer Corp.
150 Varick St.
New York 13, N.Y.
Booths 2413-2414

Hank Russell, Ted Craige, Joe Barreca, Austin Profeta, Mike Cooney, Walt Rooney, Bob Soevyn



Miniaturized High Frequency Filter

Electric wave filters, high Q coils, toroids, magnetic amplifiers, chokes, transformers manufactured to commercial and military specifications for the leading electronic equipment manufacturers in the industry. Also a complete line of over 1,000 items from stock suitable for both military and commercial requirements.

Unitek Corp., Booth 4526
See: Weldmatic Division

Universal Controls, Inc., Booths 2218-2220
See: C. P. Clare & Co.

Universal Electronics Co., Booth M-11
1720 Twenty-second St.
Santa Monica, Calif.

Edward Lacey, Eugene Cahn, William Friedman, Robert Schermerhorn

Regulated DC Power Supplies—Electronic, Magnetic-Amplifier, Transistor. Particularly new 25 amp.* transistorized units and military models.

Universal Instruments Corp., Booths 4019 & Room 610
139 East Frederick St.
Binghamton, N.Y.

▲ **Perry J. Wilson, Gordon Mayo, Gerald D. Minnick, J. D. Ahearn, F. H. Lawson**

(1) Universal Lead Straightening & Taping Machine, high speed production tool for handling Axial-Lead Components; straightens leads, tapes components, spools taped components, trims leads, bulk feeds and counts components. (2) Orienter-Tester Unit for electrical testing & automatic reject; also orienting components to correct polarity before taping.

(Continued on page 424A)

▲ Indicates IRE member.
* Indicates new product.

Information Service

providing complete information on the firms providing any specific product or service is available from the information booth at the head of the escalators on the third floor of the Coliseum.

When visiting the IRE meeting discuss your future with

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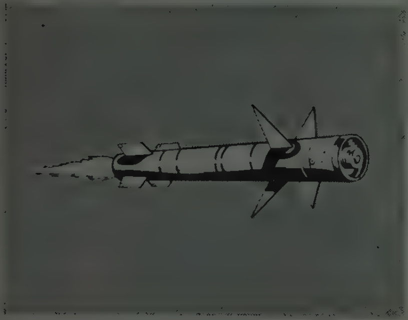
where the world of tomorrow is NOW!

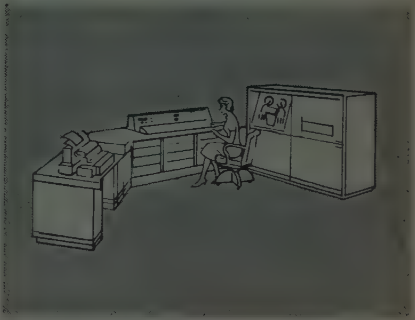


WEAPONS SYSTEMS

Radar Development • Antennas • Displays • Guidance & Control • Sonar • Advanced Systems

COMMUNICATIONS

Digital Systems • HF, VHF, UHF • Data Transmission • Audio & Video • Microwave • Forward Scatter



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Circuit Design • Input & Output • Memory Development • Test & Debugging • Field Engineering

Philco's dynamic growth continues to provide the qualified engineer advancement opportunities in all levels of engineering and management at locations in and around Philadelphia and in other attractive areas throughout the nation. We invite you to discuss your future with management representatives at any time throughout the week of March 20 to 24. If you do not plan to be in New York that week, please write to Mr. John R. Barr, Engineering Employment Manager, Department 601, 4700 Wissahickon Avenue, Philadelphia 44, Pennsylvania.

Call Mr. John R. Barr

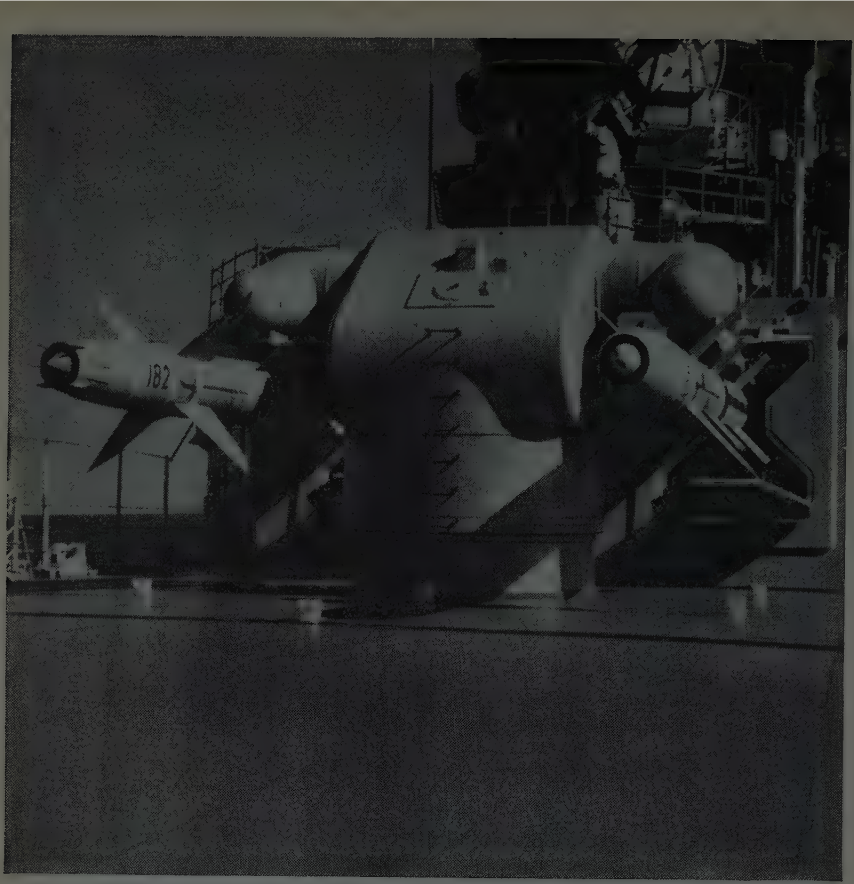
MU 8-3063

to arrange a confidential interview

PHILCO®

GOVERNMENT & INDUSTRIAL GROUP

Weapons Systems & Communications Division / Computer Division



Talos Missiles on dual launcher aboard the U.S.S. Galveston.

Take a head-on look at a prime opportunity in the missiles field!

Take a head-on look at the U.S. Navy Talos aboard the first of the missile-age cruisers, the U.S.S. Galveston. Look beyond the missiles to the organization responsible for their success—an organization which offers an increasingly wide range of missile engineering opportunities.

The established success of Talos by Bendix Missiles, its prime contractor, not only assures permanence of the present program but has opened the door to other advanced missile projects that offer new and challenging job opportunities in design, development, testing, and manufacturing.

Bendix Missiles, in addition to its direct responsibility for Talos and other advanced missile projects, is a key division of Bendix Aviation Corporation. The corporation-wide activities of Bendix cover practically every phase of advanced technology with particular emphasis on systems design and development. Participation in this highly diversified corporation effort is your further assurance of a more secure future.

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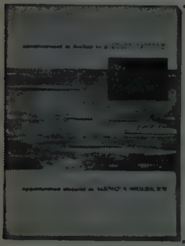
Bendix PRODUCTS DIVISION Missiles

Bendix AVIATION CORPORATION

PRIME CONTRACTOR FOR THE TALOS MISSILE



Bendix Products Division—Missiles
403D So. Beiger St., Mishawaka, Ind.
Gentlemen: I would like more information concerning opportunities in guided missiles.
Please send me the booklet "Opportunities Abound at Bendix Missiles."

NAME____

ADDRESS____

CITY__________________________STATE____________

Whom and What to See at the Radio Engineering Show

(Continued from page 422A)

Universal Mfg. Co., Inc.
1168 Grove St.
Irvington 11, N.J.
Booths 4415-4417

William A. Bernau, Anthony O. Vicari, Richard S. Hillebrand, ▲ Melvin E. Liberman

"TOROYD" Coil Winding Machine Model "S"

*New Hi-Speed Model "S" Toroidal Coil Winding Machine, featuring interchangeable "Random" or "Precision" winding heads and IC-601 Comparator for winding to desired inductance; also with Coil Clamp. Economy winding Laboratory Model L-7, Portable Taping Machines. Decade Inductors. Model U-14 Heavy Winder.

Universal Transistor Products Corp., Booths 3612-3614

See: Telechrome Mfg. Corp.

Universal Winding Co., Booths 4323-4325

See: Leesona Corporation

Utica Drop Forge & Tool Div., Kelsey-Hayes Co., Booth 4002
Utica 4, N.Y.

F. L. Marshall, F. J. Stiefvater, W. I. Pugh, H. Neff, C. Ellingwood, R. C. Bryan, L. T. Bryan, R. Dunn, A. Kufian, W. Rozmus, E. Munson

Special pliers for electronic assembly work. Midget pliers. Custom made tools for specific applications. Insulated thin blade screwdrivers. Hand powered tools for wrapping solderless connections.

Utrad Corp., Booths 1610-1618, 1709-1717

See: Litton Industries, Inc.

Valpey Crystal Corporation
1244 Highland St.
Holliston, Mass.
Booth 1429

T. S. Valpey, Jr., Nelson B. Piper, Norman R. Gillin, R. S. Puleo

Packaged oscillators*, quartz crystals for frequency control, ultrasonics and filters. Temperature control ovens. Precision optical pieces fabricated from natural and fused quartz and synthetic materials for infrared and other optical applications.

D. Van Nostrand Co., Inc., Booth 4429
120 Alexander St.
Princeton, N.J.

David Phillips, Peter H. Fagnano, Mulford Colebrook, Dayton Beguelin, E. M. Crane, Jr., Adrian Clark

The D. Van Nostrand Publishing Company will display reference books and publications on radio engineering, electronics and communications, and related subjects.

(Continued on page 427A)

Flames swept across the open plains as the Mongol hordes ran in terror from the "arrows of flying fire". When the smoke had cleared the Chinese had won the battle of Pienking with the first rocket.

Missiles have become greatly more sophisticated since this crude unguided arrow was propelled by gunpowder packed in an open-ended bamboo tube. Today, as a vital part of one of the world's largest electronics companies, Raytheon's Missile Systems Division is making significant contributions to the art of missilry. The exciting new Pin Cushion Project for selective missile identification, the constantly advancing Navy's air-to-air SPARROW III and Army's HAWK are examples of their outstanding creative work.

We are seeking highly creative people to maintain Raytheon's leadership in this challenging field. For these people, Raytheon's Missile Systems Division creates a climate for talent — perhaps *your* talent.

MISSILE:
13th CENTURY

ENGINEERS: immediate openings in Data Handling — Circuit Design — Packaging—Electro-Mechanical Design—Systems Test — Test Equipment Design — Systems Analysis — High Power Radar Design — Microwave Tube Application — High Voltage Power Supply — Modulators — Microwave Design — Systems Design — VHF Circuit Design — Operations Analysis — Radar Systems and Mathematicians.

Please apply to Mr. W. F. O'Melia, Employment Manager, Bedford Laboratory, Missile Systems Division, Raytheon Company, Bedford, Massachusetts.

RAYTHEON *MISSILE SYSTEMS DIVISION*

...creates a climate for talent.

Thinking about

CALIFORNIA?

We'll be at the Convention Hotel during IRE to discuss with SCIENTISTS and ENGINEERS the many opportunities that exist in the industry on the WEST COAST.

PROFESSIONAL & TECHNICAL RECRUITING ASSOC.

(A Division of the Permanent Employment Agency)

825 San Antonio Road
Palo Alto, California
Davenport 6-0744

(Our client pays our fees—NO CHARGE TO YOU)

Electronic and Missile Industry

UNDERSTUDY TO DIRECTOR OF ENGINEERING

A major missile and electronics company has an immediate requirement for a talented, aggressive engineering executive with a proven record of accomplishment. The man selected will work closely with the director of engineering in directing and coordinating the activities of a large (well over 1,000-man) engineering organization engaged in advanced design, product development and design, and applied research.

This outstanding opportunity requires a man with broad experience in airborne and ground electronics, together with a knowledge of configuration, aerodynamics, mechanical and electrical design problems. A familiarity with research tools and techniques is also desirable. The individual we are seeking must be capable of contributing to advanced scientific thinking and have recent experience with the organizational problems of managing a multi-hundred-man engineering department.

Location is in the southeastern United States. Compensation is excellent with unusual potential. Pleasant living in an exceptionally beautiful urban environment. Full relocation will be paid for the successful candidate and his family. Please indicate your present and desired salary in your resume. A basic degree in electronics or physics is required, with advanced degrees preferred. Your present association will be held in confidence. Reply to Box 2014, Institute of Radio Engineers, 1 East 79th St., New York 21, N.Y.

IR

SYSTEM ENGINEER

Our Radiation Systems Division has a high-level creative position now open for a candidate who has substantial formal training. The position requires experience in the application of fundamental infrared theory and technique to detection, tracking and guidance systems.

System engineering at Emerson encompasses the full spectrum of applied research, analysis, and development from initial operational analysis and preliminary system design to final system test.

This position affords unusual professional freedom and a wide degree of diversification which can be exercised in an environment of stimulating staff associates.

Emerson is located in beautiful suburban St. Louis, wonderfully convenient, with excellent educational facilities. Our fringe benefits are quite liberal.

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YOUR FUTURE IS OUR BUSINESS!

EMERSON ELECTRIC

ELECTRONICS & AVIONICS DIVISION

8100 West Florissant • St. Louis 36, Mo.

Whom and What to See at the Radio Engineering Show

(Continued from page 424A)

Vari-L Company, Inc., Booth 2209
207 Greenwich Ave.
Stamford, Conn.

▲ J. L. Kiser, Joseph H. Kiser, John McGeorge, Robert J. Ferrer, Alberto Pescatori

Vari-L electrically variable inductors, miniature, ovenized, ultra-stable types. *Vari-F packaged, transistorized sweep oscillator. *Sub-miniature V.H.F. units.

Varian Associates
611 Hansen Way
Palo Alto, Calif.
Booths 2714-2720

▲ H. Myrl Stearns, ▲ Emmet Cameron, ▲ Edward Herrold, ▲ Dr. Louis Malter, ▲ W. M. Silhavy, ▲ P. I. Corbell, R. E. Stark, ▲ W. G. Wagener, ▲ D. G. Clifford, T. J. Curtis, ▲ A. E. Acker, ▲ J. W. Summers, ▲ W. S. Rockwell, Chandler Murphy

Varian Klystron Power Supply

Microwave Tubes, including Klystrons, Backward Wave Oscillators, Traveling Wave Tubes, and related components. *Klystron Power Supplies. *X-Band Balanced Mixers. *VacIon® high vacuum pumps and *Graphic Recorders.

See also: Bomac Laboratories, Booths 2710-2712

Varo Mfg. Co., Inc., Booth 1731
2201 Walnut St.
Garland, Texas

J. R. Gilmer, Fred P. Granger, Frank Desmond

*Microcircuitry, *Transistor Inverters, Static Converters, Tuning Forks, *Demodulators, Frequency Sensitive Relays, Electronic Tachometers, Speed and Frequency Controls, Filters, Magnetic Components, Frequency Meters, and other Solid State Power and Control Devices for Military and Commercial Application.

Vector Electronic Co., Booth 4051
1100 Flower St.
Glendale 1, Calif.

▲ R. R. Scoville, Floyd Hill, Art Sloane

Structures for mounting circuitry, *Transistor Turrets, Socket Turrets, modular Plug-in Cases, *Pre-punched Terminal Board, *Terminal boards and strips, *Terminals, hardware, plugs, sockets, *Experimenter's Kits, Tube Socket and Current Test Adapters, *Pre-programming patchboards and patch cords, *Printed Circuit Cards.

Veeco Vacuum Corporation, Booths 3001-3002
86 Denton Ave.
New Hyde Park, L.I., N.Y.

Al Nerken, Bill Meoli, Dick Laken, R. L. Dietrichson, George Shinbrot, Lew Susskind, Gene Zapp

Helium Mass Spectrometer Leak Detector; Automatic 4" high vacuum Evaporator; High vacuum Valves, Pumps, Gauges and Accessories, 2" High Vacuum Pumping Station.

(Continued on page 428A)

Be sure to see all four floors!

Engineers • The Probability is High That

Your Creative Ideas

Will Reach Tangible Form at Sanders

This company owes its surprising growth (from a handful of brilliant men 8 years ago to a 1200-man organization today) to the originality of its conceptions in diverse electronic fields. (Examples of Sanders' firsts include PANAR® radar, TRI-PLATE® microwave products, FLEXPRINT® flexible printed circuits.)

If you have the capacity to father genuine technical innovations, you will find engineer-management receptive at Sanders Associates. You will be encouraged to demonstrate the practicality of a promising idea, and assisted in doing it. And you can rely on receiving professional and financial recognition for creative contributions.

Right now opportunities are available at Sanders on a variety of commercial and defense projects, including a very sophisticated seeker system for the U.S. Navy's Eagle Missile, which it is believed will provide superior performance in the face of increasingly effective countermeasure techniques.

ECM ENGINEERS

Desiring to advance the state-of-the art through new systems concepts and to translate these concepts into production.

MICROWAVE ENGINEERS

For stimulating systems study, antenna design and research leading to marketable TRI-PLATE (r) microwave products.

SYSTEMS & CIRCUITS ENGINEERS

For analysis and design of weapons systems and component parts such as receivers, transmitters, test equipment, data processing equipment and transistorized special circuits.

ANALYTICAL ENGINEERS

Data systems, weapons and countermeasures.

INSTRUMENTATION ENGINEERS

For gyro development, systems development, servo development and product engineering.

To learn more about opportunities for you at Sanders—and the advantages of our location in the progressive New England community of Nashua, New Hampshire (less than an hour from downtown Boston), send a resume to Lloyd Ware, Staff Engineer, Dept. 908.

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NASHUA, NEW HAMPSHIRE

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NEW OPPORTUNITIES IN

LOW-NOISE AMPLIFIERS SEMICONDUCTOR DEVICES
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Chicago, Ill., and Menlo Park, Calif.

The continuing expansion program at Zenith has created new opportunities for engineers with experience in the above fields

The fast-wave **electron-beam parametric amplifier,** conceived at Zenith, has opened up challenging new fields for research and development activity from UHF to SHF bands. Broad company interests in the microwave-tube area provide fertile atmosphere for original ideas and individual initiative.

An expanding research program in new fields centered around **compound semiconductors** provides opportunities for individuals with backgrounds in the solid-state art. Development of special devices for highly specific purposes, in collaboration with applications engineers, represents another area of active interest in the semiconductor field.

Positions are now available in the Research Department at Chicago; some openings are available in the San Francisco Bay Area. Congenial small-group atmosphere prevails, with all the advantages of a large, progressive company.

Interested applicants please contact:

DR. ALEXANDER ELLETT
Zenith Radio Corporation
6001 Dickens Avenue
Chicago 39, Illinois

BErkshire 7-7500

Interviewing at the Waldorf Astoria March 21 through March 24

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Representing outstanding firms throughout the nation with opportunities for the executive to the new graduate. Of course, fees are company paid, as are costs of interviews. Please send us a copy of your resume, and a letter outlining your objectives. We will treat your application immediately, in confidence, and in a fashion that will accomplish your aims.

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LAWRENCE ALLEN, DIRECTOR ENGINEERING & SCIENTIFIC PLACEMENT

ENGINEERING & SCIENTIFIC PLACEMENT DIVISION

1528 WALNUT ST. PHILADELPHIA 2, PA. KINGSLEY 5-8525

Whom and What to See at the Radio Engineering Show

(Continued from page 427A)

Veeder-Root, Inc., Booth 3908
70 Sargeant St.
Hartford 2, Conn.

C. C. Lombardi, F. J. Swords, W. T. Heydt, T. J. McLaughlin, A. T. Russo, R. W. Moller, T. L. Ellis

Precision counting instruments, for all mechanical, electro-mechanical, or electronic counting requirements. Miniaturization, ruggedization, close tolerance work, "MIL-Spec" requirements met for "Tailor-Made" counting devices.

Vemaline Products Co., Booth 1915
Box 222
Hawthorne, N.J.

Wm. Venema, N. Groenewal, Jr., K. J. Rozema, C. H. Carton, Wm. Cortos, B. Homan

*Heatsinks—*Rack and instrument handles. *Synchro motor clamps—*Collar clamps—instrument-knobs—Push button switch adaptors—Footswitches.

Vernistat Division, Booth 2828

See: Perkin-Elmer Corp.

Victor Adding Machine Co., Booth 3825
3900 N. Rockwell St.
Chicago 18, Illinois

G. W. Hasbach, ▲G. E. Sandgren

Digital Printers—Scanning Printers—Tape Punch Systems—Data Handling & Processing Systems—Remote Electrical Out Put Keyboards—Solenoid Operated Printing Calculators—Reversible Decade Counters.

Victoreen Instrument Co., Booth 2234
5806 Hough Ave.
Cleveland 3, Ohio

W. A. McCarthy, R. C. Hahn, ▲ D. O. Ward

Corotrons—Hi-Meg Resistors—Hi-Voltage Resistors—Geiger Tubes—Electrometer Tubes—Hi-Voltage Vacuum Regulator Tubes*—Gas Diodes.

Victory Engineering Corp.
Springfield Rd.
Union, N.J.
Booth 1423

B. J. Oppenheim, ▲ M. Sapoff, M. L. Miller, W. B. Huston, J. M. Ruskin, J. S. Baeck, R. Gresham, J. W. Koleszar, W. Koller, F. J. Mascuch

The Veco Chopperette

Precision made, high reliability Thermistors and Varistors; Thermal Conductivity Cells; Electronic Controls; Thermal Electronic and Physical Sensing Devices; Veco* Chopperette (Transistorized Chopper).

Virginia Electronics Co., Inc., Booth 3945
River Road & B&O Railroad
Washington 16, D.C.

Albert Cohen, Betty L. Cohen, Jane Snyder, Louis C. Athanas, James J. Karaganis, Mary Walter, Saul Cohen, D. R. Bittan, L. G. Korman, C. A. Boenecke, C. H. Emory, Wm. Shaver, Jack De Vine

Velco Circuit Programming Systems; Velco Connector Soldering Machine; *Portable Soldering Machine (for Printed Circuit Maintenance, etc.); Communication Control Systems; Contract Manufacturing; Transformers and Coils.

(Continued on page 432A)

Our civilization, our culture — even life itself — survive and thrust forward only as man and man, man and society are able to communicate one with another. Meeting the demands of society for ever-growing communications, by progressive improvements, results simply in continuously new demands for bigger, better, faster and farther communications.

Communications engineers of ITT Laboratories are engrossed in solving these myriad problems . . . finding more room in the spectrum, from direct current to cosmic rays, and finding improved means of utilizing the spectrum. Active research is underway, pushing high and low ends; in-between we are contributing to better communications through such things as parametric amplifiers, tropo-scatter microwave links, satellite communications systems, atmospheric propagation studies and global communications networks, as well as advanced computers and digital communications systems.

As an engineer you will find ITT Laboratories a stimulating and rewarding place to explore the spectrum, to work the rest of your active days toward advancing mankind's communications — on earth, in the far reaches of space, and in-between. Write Manager Professional Staff Relations to find out where you can fit into this unique organization.

ITT LABORATORIES
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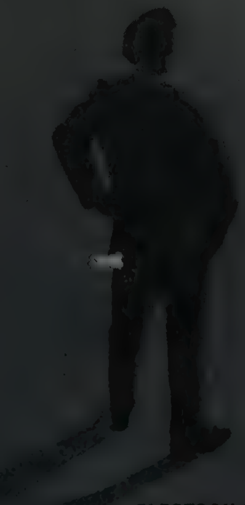
AC QUESTMANSHIP

AC Seeks and Solves the Significant—With GM's support, AC is taking giant strides toward leadership in the international technological race. And AC Reliability—characteristic of every aspect of AC's operation—plays a large role. It results in such successes as AChiever inertial guidance for Thor . . . and the more sophisticated AChiever being built for Titan. / This is AC QUESTMANSHIP. It's the scientific quest for new ideas, methods, components and systems . . . to promote AC's many projects in guidance, navigation, control and detection. / To Mr. Harold C. Yost, AC Director of Reliability, the goal of Questmanship for his group is "to find ways to make a product able to repeat its performance". They constantly seek product improvement, "making creative contributions in every area from basic design to field operation". That takes engineers with broad knowledge, imagination and experience. / You may qualify for our specially selected staff . . . if you have a B.S., M.S., or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience. If you are a "seeker and solver", write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG *The Electronics Division of General Motors*



1960

LET'S TAKE A LOOK AT YOUR PROFESSIONAL FUTURE *with CBS Electronics*

We'd like to hear about your professional plans... what incentives you need to stimulate the fullest use of your potential professional capabilities. We'd also like to tell you about the many work satisfactions enjoyed by members of the CBS professional family.

CBS ELECTRONICS is the engineering and manufacturing arm of COLUMBIA BROADCASTING SYSTEM, Inc. Consistent with our pioneering and leadership in electronics, we are utilizing our full resources on advanced technical programs in the design, development and manufacture of electron tubes and semiconductors of ultra-high quality, to meet the most exacting reliability standards for entertainment, industrial and military applications. Under engineering-oriented management, our vigorous expansion includes a modern $5,000,000 Lowell facility now nearing completion.

You and your family will live in a pleasant New England community...with beaches, mountains, educational and cultural advantages nearby...and only 45 minutes from Metropolitan Boston.

If you are qualified to assume broader responsibilities, you are invited to discuss exceptional growth positions in these areas:

ELECTRON TUBE ENGINEERS & PHYSICISTS

Electron tube development
Microelectronics development
Application engineering
Production engineering

SEMICONDUCTOR ENGINEERS & SCIENTISTS

Circuit design & applications
Production engineering
Device development
Process engineering

NEW YORK INTERVIEWS
during IRE
MARCH 21-24
For appointment, please call Harry C. Laur
Circle 7-8051
or visit the CBS Exhibit (Booth #1208 & #1210)

If unable to arrange interview, please write Mr. H. C. Laur, 900 Chelmsford Street, Lowell, Mass.

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A challenging opportunity exists now for an experienced digital computer system engineer or physicist capable of leading a team of senior system and logical design engineers in the design of a large scale radar control and data processor. Advanced degree desirable. Assignment is with a Southern California organization (outside Los Angeles) presently active in general and special purpose computer areas.

SALARY: to $20,000. If you feel you qualify for consideration, please forward a detailed resume of your background and experience to:

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1 East 79 St., New York 21, N.Y.

All replies will be held in strict confidence.

Mr. Engineer . . .

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Our business is the design, development, and manufacture of proprietary electronic data processing and data acquisition system . . . research and development study projects pertaining to satellite programs . . . varied engineering design projects and other activities with both military and commercial significance.

There's ample elbow room for the non-organization man in any one of the following professional areas:

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Systems Design
Analog Design
Systems Engineering
Digital Design
Project Management
Project Engineering
Electronic Design
Systems Evaluation and Modularization
Field Engineering
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BECKMAN INSTRUMENTS, INC., SYSTEMS DIVISION
325 North Muller, Anaheim 5, California
(25 miles south of Los Angeles, near the Pacific Coast)

Whom and What to See at the Radio Engineering Show

(Continued from page 428A)

Vitramon, Incorporated
Box 544
Bridgeport 1, Conn.
Booths 2302-2304

▲ Barton L. Weller, Clifford H. Tuttle, Jr., ▲ Jack H. Beck, Albert S. Takacs, Edmund A. Bolton, David H. Whittier, Frank E. Baron, Robert W. Hostage, Robert L. Millar, George N. Salvia, Frederick J. Toffee

"VK" Ceramic Capacitor

New "VK" micro-miniature ceramic capacitors to 10,000 mmf; 200 vdc rating; 150°C operation; modular case design; including uncased units for complete assembly encapsulation. Miniature solid-state porcelain capacitors to 6800 mmf; stability, low loss, low noise, high frequency operation at 200°C ambients.

Vitro Corp. of America, Booths 3826-3828

See: Nems-Clarke Co.

Wales-Strippit, Inc., Booth 4010
Akron, N.Y.

Norman F. Weyland, Joseph L. Stella, William A. Schrader, Arthur H. Strickland, Robert H. Tremble, David Flint, Joseph J. Miranto, Edward W. Cassidy, Bruce W. Cameron, Adrian W. Doherty, Russell A. Johnson, Arthur K. Schott

Printed Circuit punching machine in operation, complete line of press tooling for punching and notching radio, TV and electronic chassis, control panels, switchboards and instrument cabinetry. Precision Drilling-layout machine and a Screw Feeder will also be in operation.

Walkirt Co., Booth 1822
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Inglewood 3, Calif.

▲ Wes L. Kirchoff, ▲ Jim Robinson, ▲ Dave Sonkin, Lee Lebowitz, Howard Morell, Bill Sonkin

Digital & Logic Circuitry in Plug-In & Miniaturized Packages, including Binary Counters, Triggers, Gates, Multivibrators, Relay Drivers, etc. Binary Counter with component density of over 1,000,000 parts per cubic foot. Circuits shown in Germanium, Silicon & Vacuum Tube versions.

P. Wall Manufacturing Co., Booths 4517-4519
P.O. Box 71
Grove City, Pa.

M. A. Silverman, Norman Wittman, Ben Solomon, Paul Sneirson, H. H. Sherman, Alex Schoenwald

1½ oz. soldering pencils particularly adaptable for sustained heavy duty production lines. No transformers. Instant soldering guns. Thermostatic action pencil irons and regular irons. Soldering problems solved by our travelling engineers—available at no cost for this service.

(Continued on page 434A)

▲ Indicates IRE member.
* Indicates new product.

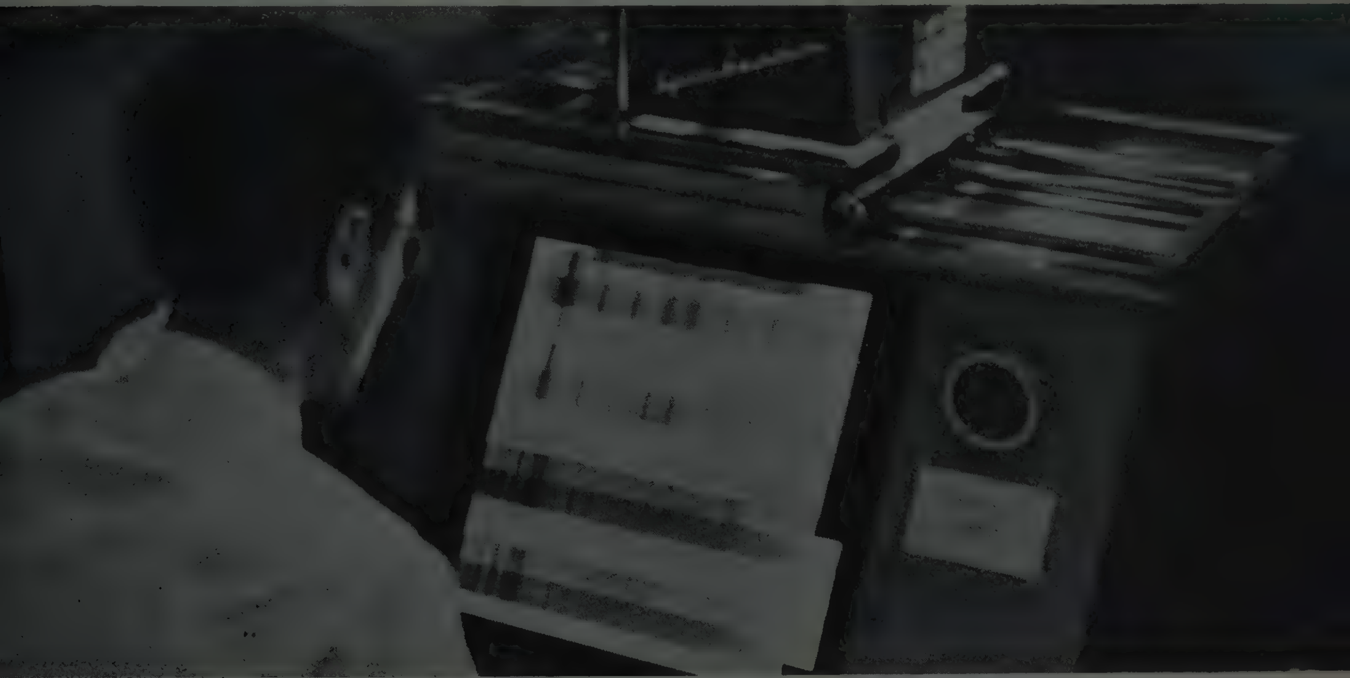
Support Facilities *such as the Materials and Process Laboratory contribute to your professional achievement at Remington Rand Univac*

Univac recognizes the engineer's need for readily available and accurate working data. For this reason the company provides support facilities staffed and equipped to give you the reliable information you need when you need it. One such supporting activity is the work of the Materials and Process Laboratory, a centralized facility devoted exclusively to furnishing data to project engineers in all areas.

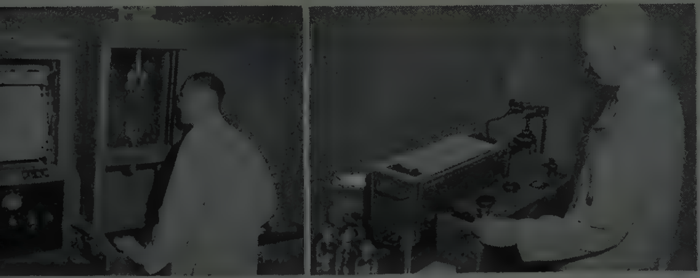
In this laboratory more than 20 physicists, chemists, metallurgists and electro-chemists, working with the most advanced equipment available, evaluate, investigate, and analyze materials now in use, materials which have failed to function properly and processes being considered for future application.

The laboratory carries out investigation involving chemical, electrochemical, chemical engineering and metallographic data.

As a Univac engineer, this laboratory and other specialized support facilities work with you in supplying technical data for your analysis as well as consulting services of specialists. This type of support is just one of the factors that helps create a favorable environment at Univac—an environment that contributes to your professional achievement.



DISPLAY SCREEN of dual grating emmision spectrograpn in Univac Materials and Process Laboratory. Spectrograph provides rapid and reliable means of identifying and estimating concentrations of elements present in an unknown. This equipment is particularly vaiuable for identifying and determining trace elements and for approximate analysis of very small samples of material.



EQUIPMENT for precision tensile testing and Spectrophotometer are also among facilities offered by Materials & Processes Laboratory.

eer opportunities for scientific personnel with training in Engineering, Physics Mathematics are available in the following areas:

Transistor Circuit Design	Business Data Processing Systems
Solid State Physics	Computer Logical Design
Computer Programming	Engineering Writing
Electro-mechanical Design	Military Guidance and Control Systems
Stress and Dynamics	Component Standards and Specifications

uiries will be given prompt and confidential consideration. Send a resume of ication and experience to:

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Remington Rand Univac

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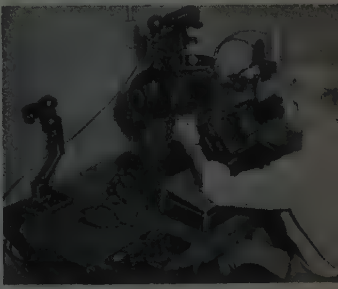
2750 West Seventh Street, St. Paul 16, Minnesota.

MODEL L Bausch and Lomb camera for macro-work is capable of subject magnification from 2X to 22X, producing either black and white or color photographs.



REICHERT METALLOGRAPH is used for micro-work. This equipment can produce negatives with a magnification of 2000 diameters, facilitates observation with pseudo-relief, dark field and polarization and has a microhardness tester to check relative hardness of individual metallic crystals.

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Division of Sperry Rand Corporation
1900 West Allegheny,
Philadelphia 29, Pennsylvania.

R. F. MARTIN—Department F-3,
REMINGTON RAND UNIVAC
Division of Sperry Rand Corporation
Wilson Avenue,
South Norwalk, Connecticut.

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Supervisory and senior positions are available for persons with backgrounds in the following fields:

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FLIGHT TEST ANALYSIS ENGINEERS

Capable of interpreting flight test data representing the complex aerodynamic/thermodynamic heat transfer, body motion, and systems function problems associated with high-speed aircraft or missiles. Duties include analyzing the test data and the development of methods to be utilized in the data interpretation.

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To analyze the effects of instrumentation, data transmission, recording, processing, and reduction on field test data. Will develop and specify techniques and methods for reducing and presenting the physical quantities required for test analysis.

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Electronics Engineers to participate in the conception, design procurement and fabrication of blockhouse, hangar and factory control checkout equipment, and ground instrumentation. Experience with electronic systems related to telemetry, radar, or CW desired.

FLIGHT TEST PROGRAM ENGINEERS

Qualified to respond to the challenge of the conceiving, originating, and directing overall flight test programs for advanced missile and re-entry vehicle systems. Experience in missile, high-speed aircraft, or airborne systems flight test is desirable.

Ground Equipment Design and Instrumentation

Several outstanding openings are available for Electrical Engineers to design ground control and checkout equipment for the Titan and Minuteman Re-entry Vehicles.

MISSILE GROUND EQUIPMENT ENGINEERING

For projects involving Operational Equipment: Automatic Programming; and Sequencing of Missile Assembly Checkout and Pre-Launch Control. A minimum of a B.S. in Electrical Engineering is required plus interest and experience in both AC and DC control circuitry, switches, relays, servos, radio interference suppression, and semiconductor applications.

Electronics & Electromechanics

MICROWAVE COMMUNICATION STUDIES

Studies of microwave transmission through various media; microwave system integration, data handling, displays, and system logic.

MISSILE ANTENNAS

Senior missile antenna and microwave system engineers.

CIRCUIT SYNTHESIS AND DESIGN

Advanced work in pulse and analogue circuitry using PAM, PPM, and PDM modulation systems. Work includes data handling equipment, modulators, demodulators, coders, and decoders, etc.

ELECTRONIC PACKAGING

Challenging assignments in packaging high power, high voltage, microwave and pulse components to operate satisfactorily in "a space" environment.

MILLIMETER WAVE TECHNIQUES

Microwave systems and components, preferably in the millimicrowave region. Some experience with solution of missile fuzing problems is desirable.

NUCLEAR FUZING SYSTEMS

Senior electromechanical engineers experienced in research, design, and development of electromechanical systems and components, preferably in the nuclear fuzing field. Positions involve challenging assignments in creating missile-borne fuzing systems that must extend present state of the art in this field.

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Responsible senior level positions are available in the research and development of HF and VHF single side band systems, transistor circuitry and frequency synthesizer systems.

This is an excellent opportunity to do either project engineering or creative developmental engineering in an expanding communications department.

The division's new suburban location provides an attractive working environment outside of metropolitan Boston and Cambridge. The extensive fully equipped laboratories are close to Boston educational institutions and cultural events and the division offers a liberal assistance program to those desiring advanced study.

Send resume to: Mr. Richard Rubino, Scientific and Technical Relations

If you are attending the IRE Show in New York and would like further information, contact the AVCO/RAD representative at the Career Center, Henry Hudson Hotel, 358 W. 58th St., opp. Coliseum, or call COlumbus 5-6138, 5-2658 or 5-2974

AVCO
Research & Advanced Development
A Division of Avco Corporation
201 Lowell St., Wilmington, Mass.

Whom and What to See at the Radio Engineering Show

(Continued from page 432A)

Wallson Associates, Inc.
912 Westfield Ave.
Elizabeth, N.J.
Booth 3006

▲ Joel P. Wallenstein, Abram S. Jaffe, H. J. Goldstein, ▲ Gerald Randolph, Marvin Elkinson, Gerard Dravis, Patrick Marshall

Wallson Model 141A, 20 Amp. Test Set

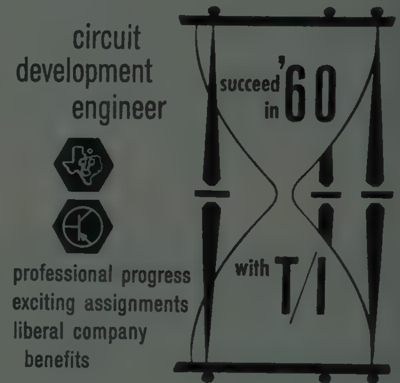
Semiconductor device test equipment and instrumentation in all power ranges. On display: portable dynamic test set with provision for surge current measurements; modular life test rack for medium power rectifiers, controlled rectifier dynamic analyzer, and equipment for thermal impedance measurements.

Wang Laboratories, Inc., Booth 3224
12 Huron Drive
Natick, Mass.

▲ A. Wang, ▲ G. Y. Chu, E. DeCrescenzo

Series TR Punched Tape Block Reader, Programmed Pulse Generator, Model 612A—Series 200 Logibloc Transistorized Digital Modules.

(Continued on page 436A)

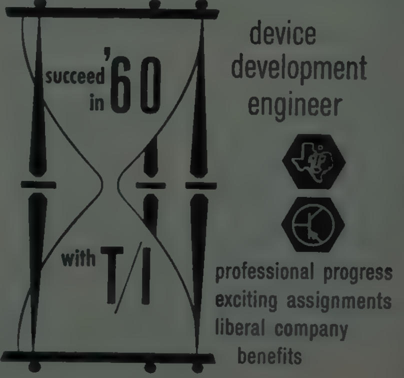


circuit development engineer

succeed in '60 with T/I

professional progress
exciting assignments
liberal company benefits

see full-page ad page 395A



device development engineer

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Plan your convention schedule to take full advantage of the technical sessions and exhibitor displays

When a technical conference of the scope of the IRE Convention comes around, your time becomes even more valuable. There is so much to see and learn, so much demanding every minute of your time—this year more than 200 technical papers and the displays of 950 exhibitors. We believe that this is a major opportunity for you to improve your knowledge of the state of the art.

We will not indulge in active technical recruiting during the convention

If personal reasons dictate that you change positions at any time during the year, we maintain permanent offices where you may discuss your interests with members of our Research and Engineering Staff.

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New York 11, N.Y.
WAtkins 9-3176

MR. SHELDON HIRSCH
336 No. Foothill Rd.
Beverly Hills, Calif.
BRadshaw 2-0661

MR. JOSEPH MULLIGAN
1135 W. Fullerton Ave.
Chicago, Illinois
LAkeview 5-7770

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Electronic Equipments Division
Beverly Hills, California

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See examples of Litton's technological versatility, and take your choice of new-product literature, at our booths: 1610-1618 and 1709-1717. If you are fascinated by exercises in deductive logic, pick up a copy of "Problematical Recreations."

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Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

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ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

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Professional Appointments

OPERATIONS RESEARCH OFFICE
ORO The Johns Hopkins University
6935 ARLINGTON ROAD
BETHESDA 14, MARYLAND

Whom and What to See at the Radio Engineering Show

(Continued from page 434A)

Ward Leonard Electric Co., Booth 2231
115 MacQuesten Pkwy. So.
Mt. Vernon, N.Y.

H. Denman, R. Dugan, H. Hayden, K. Howe, W. G. Judson, F. Kretzschmar, J. H. Leicht, R. W. Lunstead, S. E. McClure, G. Rosin, G. Platenyk, W. Schmelz, J. Scheib, A. C. Scribner, Jerry Smith, J. C. Sromovsky, R. W. Ward

Complete Vitrohm power wire-wound resistor line, MIL-R-26C resistors, Vitrohm ring type rheostats, hi-reliability relays.

Warren Wire Co., Booth 4225
Pownal, Vt.

J. R. Cook, F. W. Kunzelmann, N. K. Banks, Jr., J. H. Honour, Jr., E. V. Lane, C. H. Parker, R. W. Proctor, L. T. Russell, H. F. White

High temperature Teflon lead wires and multiconductor cables, a complete range of magnet wires including Teflon; bare, tinned and silver plated copper wire—single end and stranded; Teflon coated glass fabrics, yarns, sewing threads and cordage.

Waterman Products Co., Inc., Booths 3105-3106
2445 Emerald St.
Philadelphia 25, Pa.

William Waterman, ▲ Joseph Boyle, ▲ Pete Plotkin, John Gorman, Herman Miller

New Oscilloscopes, Versatile Military and Commercial PANELscopes® Available in Custom or Stock Models—Automatic Oscilloscope. Recently Introduced S-16-A CRAFTscope® and S-17-A POCKETscope®. Rack and Portable Oscilloscopes. Rayonic CRT Line Expanded with Three New Types and Additional Standard Types.

Waters Manufacturing, Inc.
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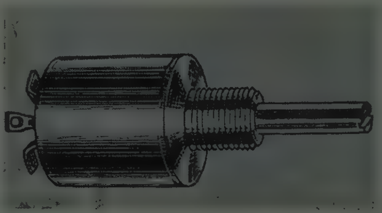
Wayland, Mass.
Booth 1233

▲ Robert A. Waters, ▲ William W. Bartell, C. R. Musello, H. A. Daziel, John Clayton, Jr., S. F. Mazzarini



APW½ "Water-tight" ½" Potentiometer

Potentiometers, Pot Hook® Panel Mounts, R. F. Coils, Slug Tuned Coil Forms, Torque Watch Gauges®, Oscilloscopes, C'TROL (Contact Meter Relay), Potentiometer Test Equipment.

Waveforms, Inc., Booth 3222
333 Sixth Ave.
New York 14, N.Y.

A. E. Byers, Wm. H. McDonald, ▲ A. Sobel

Oscillators—Audio, Ultrasonic, Carrier, All Applications; Signal Generators; Sensitive A.C. Voltmeters; Transmission Measuring Systems; Miniature Panel Mount Instruments.

Wayne-George Corp., Booth 3232
588 Commonwealth Ave.
Boston 15, Mass.

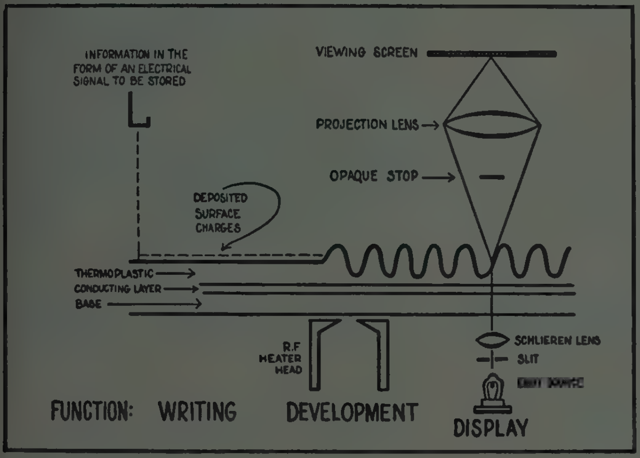
▲ George H. Wayne, ▲ Malcolm M. Bittel, ▲ Duncan G. Hunt, ▲ Sidney A. Wingate, ▲ Melvin J. Sallen, John J. Foley, John S. Blowney, Priscilla A. Smith

DIGISYN®, Type RD-13B, RD-13G* and RD-17* photoelectric shaft position encoders with accuracies from 2.5 minutes of arc to 10 seconds of arc. DIGISYN® encoder accessories including Display and Test Set*, Shift Register Module*, and Power Supply*.

(Continued on page 439A)

Join General Electric's Electronics Laboratory In Exploiting a Major State-of-the-Art Advance Promising Long-Term Impact on Many Technologies

THERMOPLASTIC RECORDING



Breakthroughs are frequently talked about, infrequently accomplished. An article appearing in the December issue of *The Journal of Applied Physics,* written by Dr. W. E. Glenn of General Electric's Research Laboratory, has stimulated the imagination of the scientific/technological community. Titled *Thermoplastic Recording,* it describes a revolutionary new method of recording electrical signals. This process makes it possible for information to be written at extremely high density by means of an electron beam on a film consisting of a low melting thermoplastic material. Data can be projected as a black and white or full color image, or it can be converted to an electrical signal. The tape can be readily erased and reused. Summarizing, *Thermoplastic Recording* provides the equivalent of a high resolution, reusable "photographic" film developed by non-chemical means in the fraction of a second.

New Programs Utilizing invention and innovation, the Electronics Laboratory at Syracuse, New York is now engaged in a growing number of programs proving the feasibility of this new process for military and commercial applications which include direct image photography, projection displays, wideband analogue recording, sonar and radio signal correlation and processing.

Anti-Submarine Warfare Program Another program of current interest includes efforts devoted to submarine detection and classification by means other than sonar, secure underwater communications and submarine-to-aircraft communication.

Professional Opportunities Highly creative and experienced engineers and physicists are required to accomplish the objectives of these ambitious programs. Major areas of professional interest should include one or more of the following areas listed to the right. ▸

A reprint of Dr. Glenn's article describing in detail the Thermoplastic Recording Process *is available upon request.*

- Geometrical, Physical and Electron Optics
- Circuit Design
- Mechanical Design
- Vacuum Technology
- Feedback Theory • Radar
- Oceanography • Television
- Sound Propagation
- Surface Physics • Sonar
- IR Phenomena

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- Materials • Circuits
- Devices • Systems
- Equipment

For further information on current openings
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GENERAL ELECTRIC
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needs ENGINEERS *with*

DOCTORS'- MASTERS'- BACHELORS'

DEGREES

for electrical, mechanical and systems work in fields of
Instrumentation—Telemetry
Anti-Submarine Detection Systems/Operations Research
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Please send resume to W. C. WALKER
ENGINEERING EMPLOYMENT MANAGER

Other High-Level Electronic
Engineering Positions Available

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION
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ONE DOOR TO ALL NEW ENGLAND

AN EMPLOYER SPONSORED SERVICE—Our employer client assumes all expenses.

THE NEW ENGLAND CLEARING HOUSE FOR ENGINEERS—Save time while getting maximum coverage by letting us act as your personal representative.

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Two immediate openings:

ELECTRONIC SPECIFICATION ENGINEERS

Prepare specifications which adequately describe the performance and design of complete missile and radar systems. Basic electronics or physics degree or an equivalent plus a minimum of at least two years in missile systems, radar or similar equipment required.

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Prepare technical progress reports for the government or prepare handbooks on operation, service, maintenance and overhaul of missile and radar systems. Minimum of two years experience in writing for advanced electronic equipment and the ability to analyze complex equipment required.

You will join one of the most progressive expanding organizations in the weapons system field today and will benefit in its growth as well as to grow and develop in your profession according to your contributions.

Please send three copies of your resume, including present salary and salary requirements to—Robert M. Hale—Account Manager

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Suite 2, 21 School Street, Boston 8, Mass.

Outstanding opportunity for men with development experience in

SOLID STATE DEVICES

If you are a Physicist, Chemist, Metallurgist or Electrical Engineer, and have experience in solid state development, or in related fields, you are invited to investigate one of the several very interesting positions now open at IBM.

We are greatly expanding our development work in the theory, design and technology of solid state devices for use in new advanced computer systems.

This is an outstanding opportunity for experienced scientists and engineers who wish to undertake new and interesting work in this field. Recent graduates, who have done work in this field, are also invited to apply.

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Product Development Laboratory
IBM Corporation, Box 390
Poughkeepsie, N.Y.

IBM.
INTERNATIONAL BUSINESS MACHINES CORP.

Whom and What to See at the Radio Engineering Show

(Continued from page 436A)

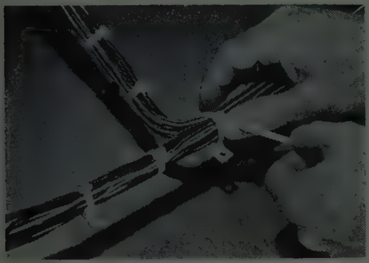
Wayne Kerr Corporation, Booths 3827-3829
1633 Race St.
Philadelphia 3, Pa.

▲ Boyce M. Adams, Gordon L. Ball, John Robertshaw, Jr., John Gruenberg II

B-921 Comparator; B-821 Low Impedance Comparator; Absolute Standard of Low Capacitance; Audio and radio Frequency Impedance Bridges, Audio and video Oscillators; Microwave Wattmeters, Vibration meter, electronic micrometer, transistor test equipment; Attenuator.

Weckesser Co.
5701 Northwest Highway
Chicago 46, Ill.
Booth 4003

H. A. Ewalt



Cable Clamps

Nylon, Teflon & Ethocel cable clamps; *new nylon Wedge Lock Band Clamps & separate mounting tabs; nylon half-clips, snap clips, & heavy duty clamps; nylon plain washers; *nylon perforated strapping & ratchet buckles; molded screws, nuts, set screws, hex & cap nuts; threaded rod; plastic & metal stampings; molding & extrusion.

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Indianapolis 5, Ind.

Arthur W. Welch, James A. Eastham, Evelyn L. Welch

Toroidal chokes, transformers, magnetic amplifiers, and universal wound coils. Most units may be molded in epoxy to your or Government specifications.

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Manufacturing Co.
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Booth 4214

John Gutsmiedl, Don Coglianese, Lester Evenson

Duo-Seal Vacuum Pumps—Vacuum Gauges—Vacuum Accessories—Densitometers—Electrical Meters—Charts.

Weldmatic, Division of Unitek Corp., Booth 4526
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Pasadena, Calif.

Gerald E. Woods, Alex H. Davidson, John Weatherman

Precision welding equipment. Seventeen different models and types to meet any metal joining requirement in laboratory or production quantities. Equipment available includes five different power supplies and four different types of handpieces and miniature and heavy duty welding heads.

(Continued on page 440A)

▲ Indicates IRE member.
* Indicates new product.

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offers all 3 most important position considerations:

CAREER OPPORTUNITIES based on solid, long-term growth . . .
TOP EARNINGS fully commensurate with experience . . .
CHALLENGING ASSIGNMENTS made possible by project diversification.

STAVID has immediate openings in career opportunities in airborne, shipboard and ground-based systems and equipment. Degree or graduate degrees, Electrical or Mechanical Engineering, Physics or Math. Positions available at all levels in research, design, development and field service engineering.

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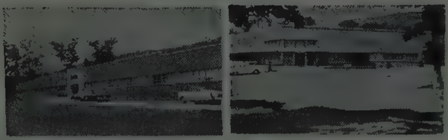
- Advanced Designs
- Countermeasures
- Systems Analysis
- Missile Guidance
- Bombing & Navigation
- Logic Design
- Data Transmission
- Display Development
- Missile Detection
- Applied Mathematics

RADAR SYSTEMS

- High-Power Modulation
- UHF & VHF Development
- Antennas
- Receivers & Transmitters
- Transistor Applications
- Microwave Development
- Digital Techniques
- Electro-Mechanical Packaging
- Pulse Circuit Techniques
- Telemetry
- I.F. & Video Circuitry
- Environmental Testing



STAVID's facilities in Plainfield, New Jersey, at the foothills of the Watchung Mountains, are near excellent schools, modern shopping facilities and ample housing accommodations. With New York City just 45 minutes away, and the New Jersey shore within one hour's drive, the Plainfield area provides an ideal environment for work, recreation and comfortable suburban living.

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PLAINFIELD 7-1600 (Plainfield, N.J.)

or send resume to:
J. R. CLOVIS, Personnel Dept. IR-3

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STAVID DIVISION
U.S. HIGHWAY 22, PLAINFIELD, NEW JERSEY

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PROPAGATION

CONTROL SYSTEMS

MICROWAVE COMPONENTS

SYSTEMS ANALYSIS IN
Missiles
Space Systems
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Whom and What to See at the Radio Engineering Show

(Continued from page 439A)

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Manufacturer of Soldering Guns, Magnastat Soldering Irons, Power Sanders, and Power Sabre Saw.

Western Gold & Platinum Co., Booths 4201-4203

See: Wilbur B. Driver Co.

Western Lithograph Co., Booth 4402

See: Westline Products Div.

Westinghouse Air Brake Co., Booths 2122-2124

See: Union Switch & Signal Div.

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W. A. Johnson, P. A. Gallagher

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Robert Richter, Bob Bohne, Ben Birken

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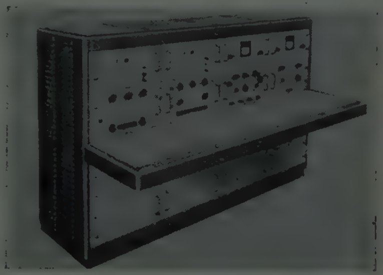
Booths 1708-1710 & 1809

▲ Emil Nichols, ▲ Roy Putnam, ▲ Richard Curley, ▲ Jim Edmonds, ▲ Charlie Gillman, ▲ Bob Morris, ▲ Jim Devine, ▲ Art Boice, ▲ Harry Raub, ▲ Jack Brown, ▲ Jerry Allen, ▲ Vernon Gray, ▲ John Kozma



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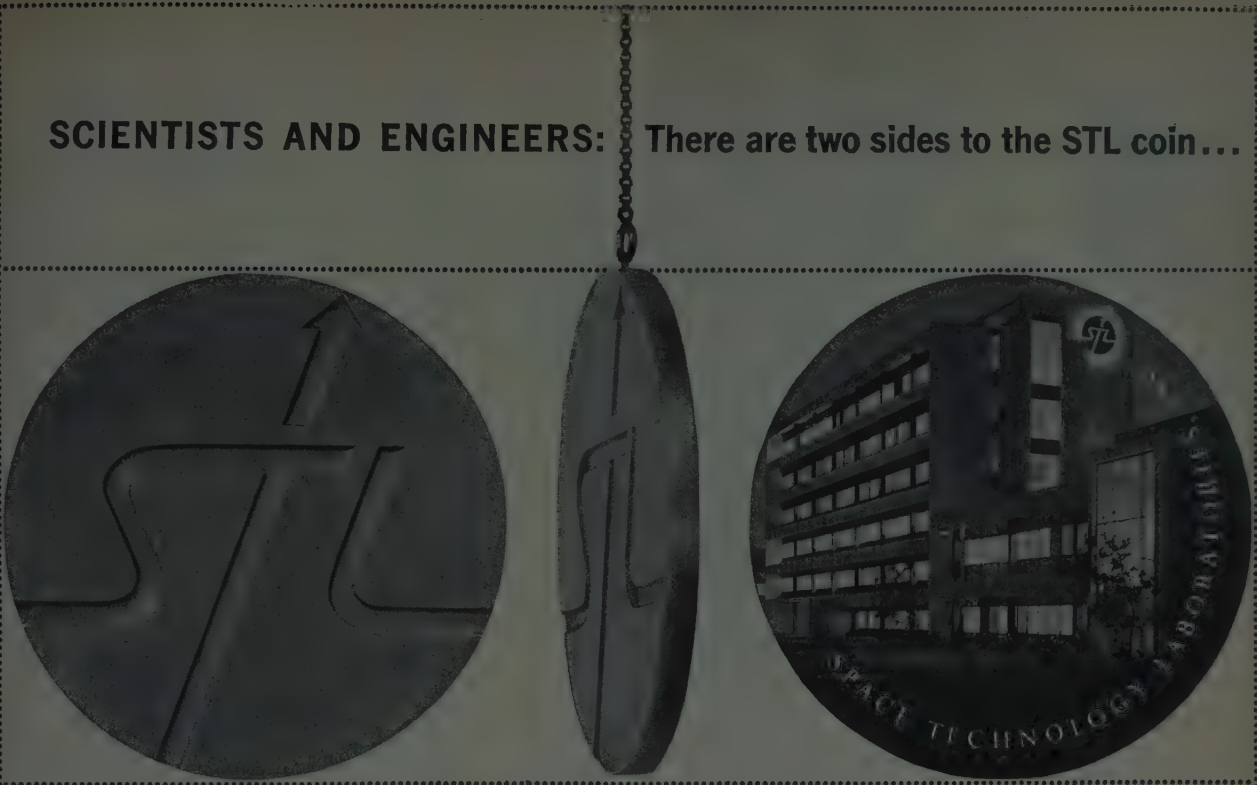
(Continued on page 442A)

SCIENTISTS AND ENGINEERS: There are two sides to the STL coin...



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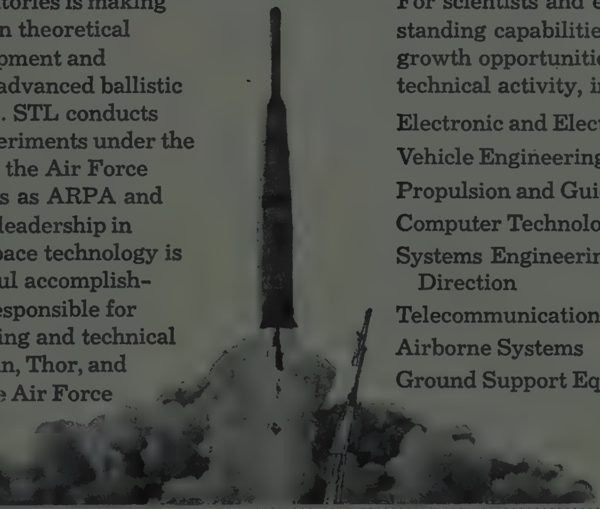

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DURING I.R.E. SHOW
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CURTISS-WRIGHT CORPORATION
631 CENTRAL AVE. • CARLSTADT, N. J.

Whom and What to See at the Radio Engineering Show

(Continued from page 440A)

Westrex Corporation, Div. Litton Industries, Inc., Booths 1610-1618 & 1709-1717
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New York 11, N.Y.

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Roger White Electron Devices, Inc., Booths 1610-1618, 1709-1717
See: Litton Industries, Inc.

Whittaker Gyro, Booth 2128
See: Telecomputing Corp.

(Continued on page 445A)

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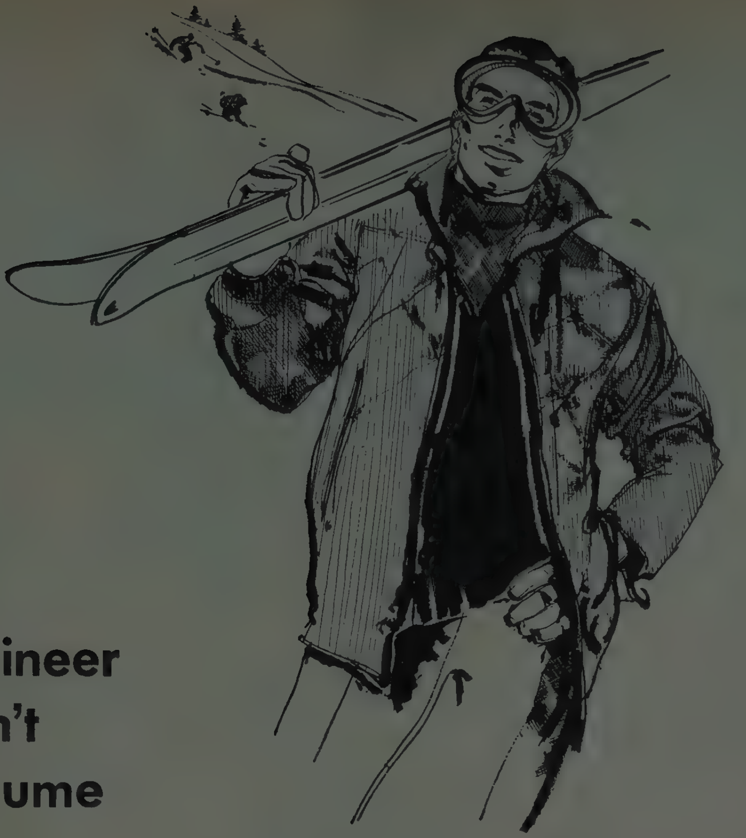

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Whom and What to See at the Radio Engineering Show

(Continued from page 442A)

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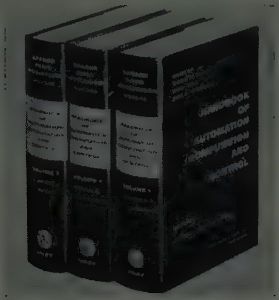
Booth 4326

Walker G. Stone, Charles B. Stoll, John W. Gorsuch, Albert R. Beckett, Albert M. Dowden, Thurman R. Poston, Donald Partenfelder



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Willor Mfg. Corp., Booth 2002
See: Camblock Corp.

H. A. Wilson Division, Booths 2110-2118
See: Engelhard Industries, Inc.

(Continued on page 448A)

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Southern Research Institute has openings for senior electronic engineers or engineering physicists in the field of instrument development. Current activities on an expanding series of projects can be summarized by the title Photoelectronics. Successful progress on the work calls for advancing frontiers in electronic circuits, physical and geometrical optics, and kinematic design of instrument components.

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- Space Radiation Measurement and Detection
- Satellite Communication Systems
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- World-Wide Communications Networks
- Command Control & Information Processing
- Micro-Electronics
- Linear Accelerators
- Gamma Rays
- Nuclear Fission
- Remote Handling Devices
- Photoconductive Materials
- Electroluminescence
- Solid State Display Devices
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- Radar Closed Loop Tester
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- Telemetering Systems
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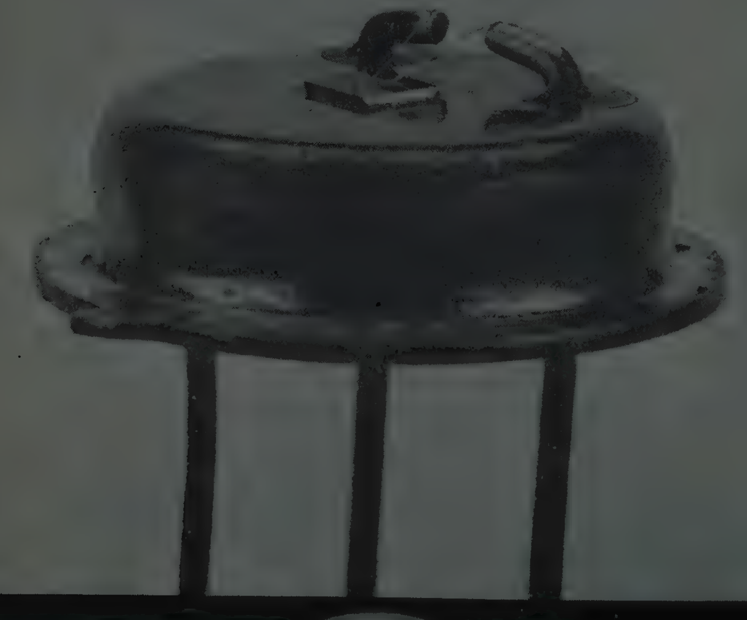

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Whom and What to See at the Radio Engineering Show

(Continued from page 445A)

Winchester Electronics, Inc., Booths 2121-2123
19 Willard Road
Norwalk, Conn.

▲ Donald R. De Tar, L. E. Harrod, E. C. Quackenbush, John Lynch, Herbert Sherman, Larry Bordeau, Frank Cowe, Louis Bencze, James Murphy, Joseph Roos, Al Octavio, Robert Thornley

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(Continued on page 450A)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 21-24, 1960

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New York Interviews

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Send resume to: Mr. A. M. Johnston, Dept. 262

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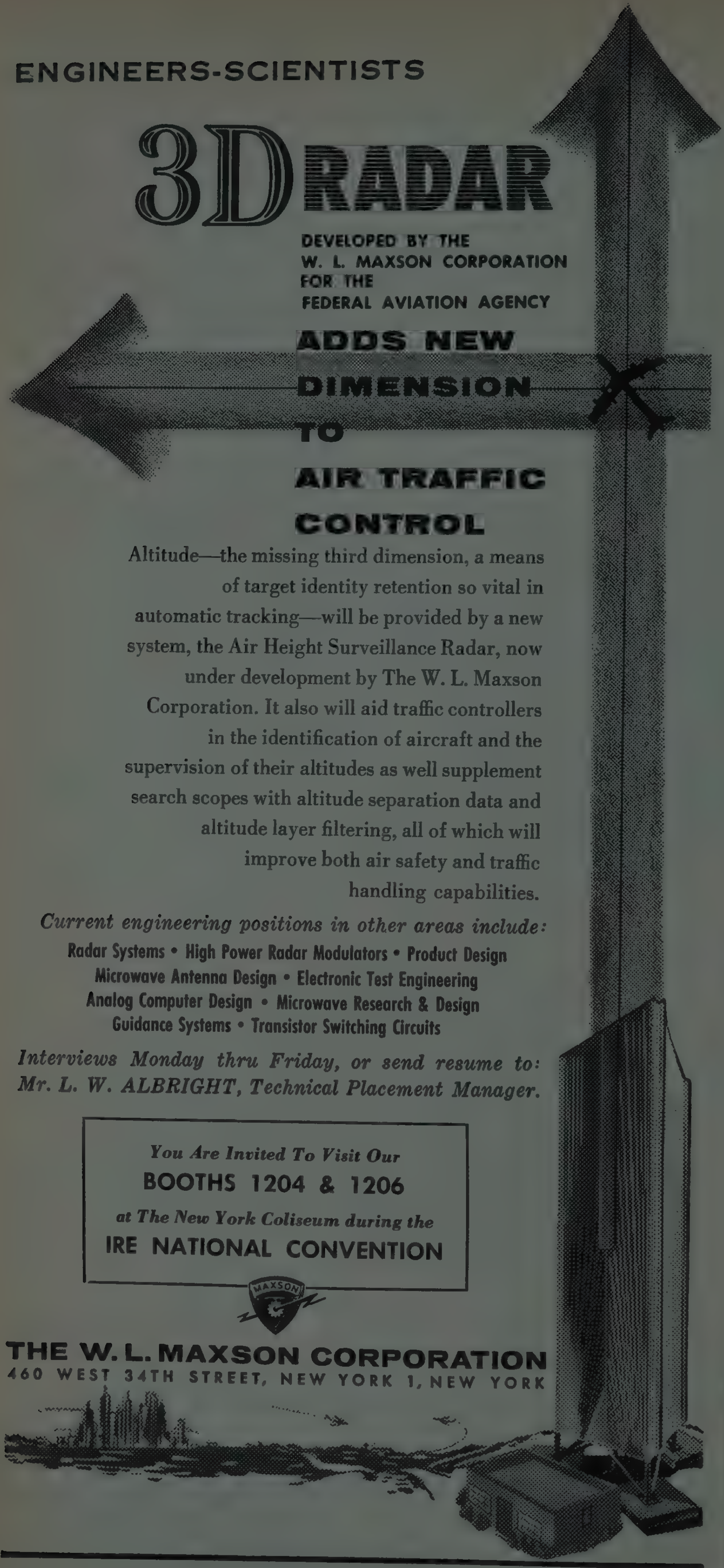

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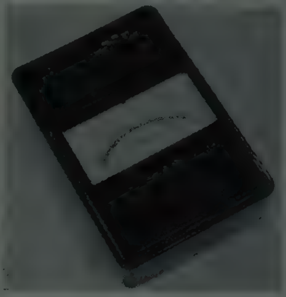
460 WEST 34TH STREET, NEW YORK 1, NEW YORK

Whom and What to See at the Radio Engineering Show

(Continued from page 448A)

Yokogawa Electric Works, Inc.
40 Worth St.
New York 13, N.Y.
Booth 3054

Ken Sadohara, Toshi Sasaki, Karl A. Kopetsky, Yukio Horie, Bernard Fox



New MODEL TPF Thermo Milliammeter

Portable Precision Instruments: Model TPF Thermocouple Type HF Milliammeters & Voltmeters, covering up to 5 megacycles, Model MPF Moving Coil Type DC, Model SPF Moving Iron Type & Model CPF Rectifier Type AC Ammeters & Voltmeters: Portable Insulation Tester: Model L-5: Vacuum Thermocouples.

York Metal Products, Inc., Booth 4239
350 Greenwich Street
New York 13, N.Y.

Alvan Bisnoff, Steve Bucek, David Fox, Claude Bisnoff

Custom precision sheet metal fabrication, chassis, panels, cabinets, instrument cases, racks, subassemblies, angle iron and aluminum weldments. Bracket fabrication and assembly. Complete finishing facilities, baking enamels, hammertones and wrinkles.

Zagar, Incorporated, Booth 4241
24000 Lakeland Blvd.
Cleveland 23, Ohio

John P. Mrsnik, Frank G. Zagar, Frank J. Zurga, Beverly D. Smith, Chas. M. Powers, Harry J. Hutter

Multiple spindle Quick Change Printed Circuit Drilling Equipment Drilling from 2 to 2,000 holes in one pass. Zagar Air Oil unit to illustrate and demonstrate method for drilling printed circuit boards.

Zell Products Corp., Booth 4108
276-80 Main St.
Norwalk, Conn.

Burton B. Zell, Sol Young, Russell Cameron, Don Bitko, Bradley Anschutz, Joe Smith, Al Seprinski, Bill Sansouci, Dean Lucas, Hal Castle, Jim Barnett, Art Hansen

Glass to Metal Hermetic Seals, Kovar Stampings, Transistor Stems for Military and Industrial Applications (TO-5—TO-18). Multi Headers, Diodes, End Seals, Terminals, Connectors, Matched and Compression type plated to required finish—to pass CP4, Mandrel Bake and Solderability Tests.

Zenith Radio Corporation
6001 Dickens Ave.
Chicago 39, Ill.
Booth 3948

▲ Ed Dervishian, Scott Morency, Tom Storey, Don Anderson, ▲ William Van Slyck

Electron beam parametric amplifier and equipment to demonstrate 1 db noise figure. Portable secondary time standard. Central Electronics 100 v single sideband transmitter. Flash X-Ray Equipment.

(Continued on page 452A)

ELECTRONIC ENGINEERS TO KEEP HIM ON COURSE

Electronic Engineers: It's Time To Set Your Course With The World Leader In Continuous Wave Doppler Navigation Systems

The "helmsmen" of space are the electronics engineers. Ryan Electronics needs scores more of them right now.

Electronics engineers to probe more and more into space and find out how to adapt the doppler principle to man's farthest reach into the future. Electronics engineers to expedite Ryan's multi-million dollar Navy and Army contracts and other challenging projects. Electronics engineers to keep a jump ahead of each new demand of America's major military aircraft and space projects. Ryan's leadership in C-W doppler techniques has accounted for its rapid expansion to more than 375,000 square feet of the most modern facilities for research, development and production in San Diego and Torrance in Southern California. Here is your opportunity to combine challenging work, a bright future and life in an area famous for ideal year-round climate, excellent facilities for graduate work, fine schools for your children. For full particulars, send your resume or write for a brochure to Ryan Electronics, Dept. 1, 5650 Kearney Mesa Road, San Diego 11, California.

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DIVISION OF RYAN AERONAUTICAL COMPANY, TORRANCE, CALIFORNIA, SAN DIEGO, CALIFORNIA

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at General Electric's Defense Systems Department

Work in the area of vast-scale total systems at DSD calls for a special type of engineer: one whose natural talents for broadly diversified responsibility have been carefully developed through wide-ranging experience and achievement in more than one sub-discipline. Naturally, really top-notch men of this kind are hard to come by—which is why...

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We'll provide the opportunity, the training, the programs and the encouragement to develop your talents into the top ranks of systems engineering.

You advance through a series of stepping-stone assignments requiring the exercise of increasing technical leadership and supervision. Your assignments are designed to give you a broader background of experience and increased technical competence. As fast as your new abilities are demonstrated, large areas of additional responsibility will be delegated. Your progress is continuously aided and encouraged by an organization aiming to fill top posts with capable systems specialists developed from its own ranks.

Your gateway to a systems engineering career is your experience in any of the following areas:

GUIDANCE EQUATIONS • INERTIAL GUIDANCE & NAVIGATION • RADIO GUIDANCE • SPACE PHYSICS • INFORMATION THEORY & NOISE • OPERATIONS ANALYSIS • DATA TRANSMISSION & JAMMING • ELECTRONIC EQUIPMENT DESIGN & TEST • INFRARED • RADAR

Please reply fully in confidence to Mr. E. A. Smith, Box 3-F

DSD DEFENSE SYSTEMS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC
300 South Geddes Street, Syracuse, N. Y.

Whom and What to See at the Radio Engineering Show

(Continued from page 450A)

Zero Manufacturing Co., Booth 4118
1121 Chestnut St.
Burbank, Calif.

Joe E. Daniels, Richard Belle Isle, Harry Halinton, Dan Greene, Lou Ackerman, Jerry Bouton, L. G. White, Robert Deunk

Complete line of packaging for the electronic industry including *new Zero Modular Re-Usable Shipping/Storage Container System, Deep Drawn Aluminum, Magnesium and Alply Transit Cases.

Zippertubing Co., Booth 4044
752 South San Pedro St.
Los Angeles 14, Calif.

H. R. Edwards, Jack Mills, Lynd Walking, W. T. Murray, R. A. Murray

"Zippertubing" provides speedily applied protection for cable and cable assemblies against heat, cold, abrasion, moisture, RF interference, chemical agents, etc. A wide variety of materials and types available.

NUMERICAL LISTING OF EXHIBITORS

Use this listing of exhibitors arranged in numerical order to help in interpreting the information given in the product listings which begin on page 468A.

A complete alphabetical listing of exhibitors, including the names of personnel manning the exhibits, and the products to be exhibited, begins on page 140A.

FIRST FLOOR

Main Lobby—The Institute of Radio Engineers
Proceedings of the IRE
The IRE Directory
Membership Information Service
1100 The Constanta Co. of Canada Ltd.
1100A Consolidated Resistance Co. of America, Inc.
1100B The Sibley Company
1101 Technical Appliance Corp.
1102 Fenwal Electronics, Inc.
1103 Avnet Electronics Corp.
1104 Autotronics Inc.
1105 Silicon Transistor Corp.
1106 Aircom, Incorporated
1107 Line Electric Co., Inc.
1108 Axel Brothers Inc. Electronics Div.
1109 Glass-Tite Industries, Inc.
1110 Applied Research Inc.
1111 Emerson & Cuming Inc.
1112 Columbia Technical Corp.
1113 ACF Industries, Inc. ACF Electronics Div.
1114–1115 Motorola, Inc. Semiconductor Products Div.
1116 Nicad Division Gould-National Batteries, Inc.
1117 Collins Electronics Mfg. Corp.
1118 A. W. Welch Manufacturing Co.
1119 Gordos Corporation
1120 Columbus Electric Mfg. Co.
1121 Three Point One Four Corp.
1201–1203 Helipot Div. Beckman Instruments, Inc.
1202 Dynamics Corporation of America Radio Engineering Laboratories, Inc.
1204–1206 The W. L. Maxson Corp.
1205 Shockley Transistor Corp. Sub. Beckman Instruments, Inc.
1207–1209 Diamond Antenna & Microwave Corp.
1208–1210 CBS Electronics
1211–1215 Burroughs Corporation Electronic Tube Div.
1212–1214 General Transistor Corp.
1216 Chicago Standard Transformer Corp.

(Continued on page 454A)

IN SAN DIEGO . . .

Electronics Engineering Opportunities

Unique civilian opportunities are available now for Electronic and Electrical Engineers at the U.S. Naval Repair Facility, San Diego. Field includes laboratory work, electro-magnetic propagation studies, and preparation of audio and visual amplifier and switching circuitry for complex communication and distribution systems.

Career Civil Service positions with salaries ranging from $7510 to $8230, and outstanding leave, insurance and promotion benefits.

Three years of professional engineering experience required, including one year of electronic engineering.

Submit resumes and inquiries to:
Industrial Relations Department
U.S. Naval Repair Facility
San Diego 36, California

U. S. NAVY

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EE with 6 years experience in circuitry, transients, and transistor application. Will supervise development project on communications and frequency standard ....$10-$12,000

PROJECT ENGINEER

EE with 4-6 years experience with transistor circuitry and knowledge of reaction of transistors at extreme environmental conditions ..to $12,000

SYSTEMS ENGINEER

EE with minimum of 6 years systems experience. Plan and direct studies in field of communication radar systems ....$1[illegible] 000

PHYSICISTS

BS, MS and PhD with experience in solid state, semiconductors, electron emission, microwave vacuum techniques, nuclear studies, etc. ....$7,500 to $15,000

PROJECT LEADER—OPTICS

Head design and development of optical systems and components for infra-red detection ......to $19,000

SENIOR CIRCUIT DESIGN

5 or more years experience in design. Develop and test transmitters, computers, and receivers ....to $17,000

COMMUNICATION ENGINEERS

New division; engineers are needed at all levels—Juniors to managers who have had experience in Tropospheric, Scatter propagation, Multiplex TV, Microwave systems and components, and antennas. Unusual promotional opportunities ....$7,500 to $18,000

COMPUTER ENGINEERS

Digital to Analogue	to $16,000
Logical Design	to $15,000
Scientific Programmer ...	to $15,000

MANAGER

Radar receiver and microwave. Manage 4 engineering supervisors and 50 engineers. Designing radar antennas, microwave, coupling and receivers ....to $20,000

APPLICATION ENGINEER

Must have minimum of 3 years of transistor circuit design experience. Will act in capacity of consultant to customers on semi-conductor problems ....to $12,000

ELECTRONIC ENGINEER

EE with extensive experience in antenna propagation and radiation. Microwave and electromagnetic theory. Excellent opportunity in a growing small company run by engineers $15,000

PROJECT ENGINEERS

Either electrical or mechanical engineers with 7 to 10 years experience with emphasis on applied mechanics, precision instruments, radar, synchros and servo motors, missile research and developments, digital and analogue computer, etc. ..$8-$12,000

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PULSE DOPPLER RADAR ENGINEER

Applicant must have a BS/EE degree plus graduate work in mathematics and electrical networks. Should have minimum of three years' experience in the design of radio frequency "front ends" for pulse doppler radars, with specific development experience in at least two of the following:

1) Highly stable, high frequency oscillators.
2) High power, fast recovery duplexers.
3) Master oscillator — power amplifier (MOPA) tube chains at microwave frequencies.

Familiarity with high power travelling wave tubes, backward wave amplifiers and backward wave oscillators is desirable.

Successful applicant will be responsible for generation of system specifications, initial design, and development of all facets of radio frequency circuitry for pulse doppler radars.

ANTENNA ENGINEER

Applicant must have an advanced degree in physics or communications engineering, with emphasis on electromagnetic theory and advanced mathematics. He must also have at least two years' experience beyond school in fundamental design and formal mathematical analysis of microwave antennas. Of particular importance is design experience with flush mounted antennas, two dimensional arrays, electronically scanned antennas, and dielectric lenses. Experience with monopulse antennas and microwave phase shifting techniques is also desirable.

The engineer who qualifies for this position will be responsible for leading initial antenna research and design, and for conceiving satisfactory theoretical solutions to radiation and scanning problems with only fragmentary information.

These career opportunities are immediately available at Emerson Electric's modern facilities in suburban St. Louis, Missouri.

In a climate of creative freedom, continual expansion and clearly outlined programs for the future, our engineers are daily influencing the state of the art. We emphasize research, design, and development with a healthy balance of production — both military and commercial.

Emerson Electric is a well-established, dynamic organization with 900 engineers and 5,000 employees. Salaries and benefits are top level. Our beautiful suburban location is ideal in every way. All moving expenses are fully paid.

If either of the above positions holds genuine appeal, wouldn't it pay to investigate the possibilities for you at Emerson?

Write in strict confidence to A. L. Depke.

YOUR FUTURE IS OUR BUSINESS!

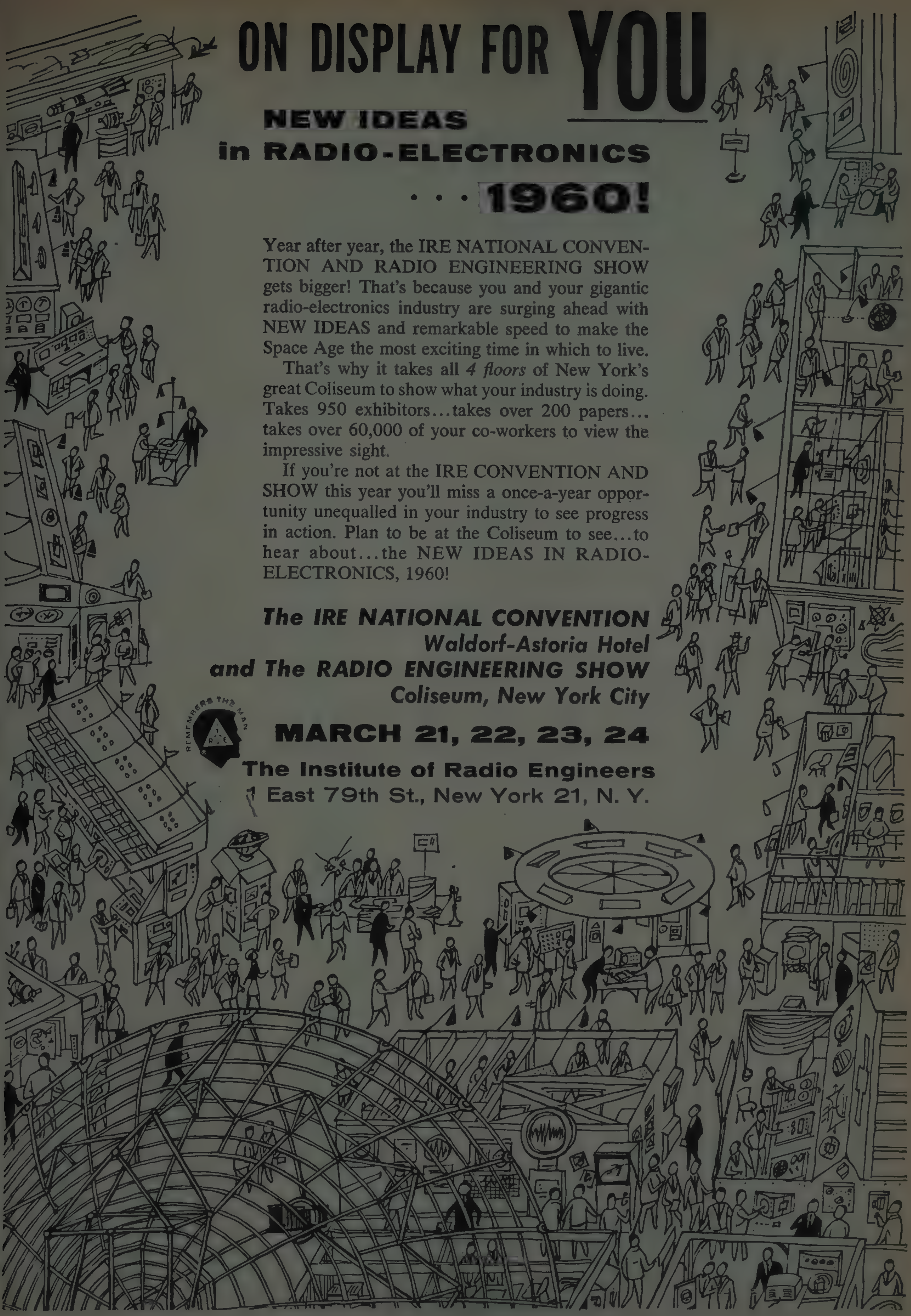
EMERSON ELECTRIC
ELECTRONICS & AVIONICS DIVISION
8100 West Florissant • St. Louis 36, Mo.

Numerical Listing of Exhibitors

(Continued from page 452A)

1217 Airflyte Electronics Co.
1218–1224 General Instrument Corp.
  Automatic Manufacturing Division
  Defense Products Div.
  Semiconductor Division
  Micamold Electronics Mfg. Corp.
  Radio Receptor Co., Inc.
  F. W. Sickles Company
1219 Engineered Electronics Co.
1221 Ainslie Corp.
1223 Hermetic Seal Corp.
1225–1227 Standard Electrical Products Co.
1226 Delco Radio Division
  General Motors Corp.
1228 Sterling Precision Corp.
1229 A.P.M. Corporation
1230–1232 Travco Associates
1231 Electro-Mechanical Instrument Co.
1233 Waters Manufacturing, Inc.
1234 Rotating Components, Inc.
1301–1309 Dynamics Corporation of America
1301–1303 Radio Engineering Laboratories, Inc.
1302–1308 Philco Corp.
  Lansdale Tube Co. Div.
1305–1307 Reeves Instrument Corp.
1309 Reeves-Hoffman Div.,
  Dynamics Corp. of America
1310–1312 General Ceramics Div.
  Indiana General Corp.
1311 Pyramid Electric Company
1313–1315 C W S Waveguide Corp.
1314–1316 Indiana Steel Products Div.
  Indiana General Corp.
1317 Telrex Labs.
1318 Bliley Electric Company
1319–1323 Transitron Electronic Corp.
1320–1322 L. L. Constantin & Co.
1324 The Korfund Co., Inc.
  Federal Div.
1325 Craig Systems, Inc.
1326 Arthur Ansley Manufacturing Co.
1327 Crucible Steel Co. of America
1327A Ind. Develop. Eng. Assoc. Inc.
1327B Reeves Soundcraft Corporation
1328 National Union Electric Corporation
1329–1331 Burndy Corporation
  Omaton Div.
1330–1332 John Oster Mfg. Co.
  Avionic Division
1333 PCA Electronics Incorporated
1400 Chicago Telephone Supply Corp.
1401–1407 National Co., Inc.
  Servo Dynamics Corp.
1402–1408 Westinghouse Electric Corp.
1409–1421 Texas Instruments Incorporated
  Apparatus Div.
  Component Sales
1410–1412 P. R. Mallory & Co., Inc.
1414 Radio Materials Co.
  Div. of P. R. Mallory & Co., Inc.
1416–1418 Perkin Engineering Corp.
1420–1422 The A. W. Haydon Co.
1423 Victory Engineering Corp.
1424 Instruments for Industry Inc.
1425 The Deutsch Company
  Electronic Components Div.
1426 Haydon Switch Inc.
1427 Telerad Mfg. Corp.
1427A–1427B Magnetic Amplifiers, Inc.
1428–1430 Giannini Controls Corp.
1429 Valpey Crystal Corporation
1431–1433 Thompson Ramo Wooldridge Inc.
1432 Magnetic Metals Co.

(Continued on page 456A)



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Year after year, the IRE NATIONAL CONVENTION AND RADIO ENGINEERING SHOW gets bigger! That's because you and your gigantic radio-electronics industry are surging ahead with NEW IDEAS and remarkable speed to make the Space Age the most exciting time in which to live.

That's why it takes all *4 floors* of New York's great Coliseum to show what your industry is doing. Takes 950 exhibitors...takes over 200 papers... takes over 60,000 of your co-workers to view the impressive sight.

If you're not at the IRE CONVENTION AND SHOW this year you'll miss a once-a-year opportunity unequalled in your industry to see progress in action. Plan to be at the Coliseum to see...to hear about...the NEW IDEAS IN RADIO-ELECTRONICS, 1960!

The IRE NATIONAL CONVENTION
Waldorf-Astoria Hotel
and The RADIO ENGINEERING SHOW
Coliseum, New York City

MARCH 21, 22, 23, 24

The Institute of Radio Engineers
1 East 79th St., New York 21, N. Y.

professional opportunities at Honeywell Aero

APPLIED RESEARCH

This department must expand 100% in the next three years to explore many new areas and provide direction for the fast growing Aeronautical division. Opportunities for engineers and scientists exist in these areas of current investigation: computer systems, optics, inertial sensors, human factors, systems analysis, instrumentation and automatic controls. A few of the specific requirements are:

INSTRUMENTATION ENGINEERS: engineering physicists to investigate new instrumentation concepts, conduct experiments and make comparative evaluations of instrumentation feasibility.

SYSTEMS ANALYST: capable of conducting research studies involving new techniques of space navigation and guidance.

ASTRO PHYSICIST: for analysis of physical phenomena in space flight, including energy absorption and conversion studies.

DIGITAL EQUIPMENT ENGINEER: for research in digital logic or circuitry for application in navigation and guidance systems.

ELECTRON DEVICE PHYSICIST: capable of independent research in molecular physics connected with generation of radiation and/or plasma devices.

PROGRAMMER ANALYST: mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

HUMAN FACTORS ENGINEER: capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

If you desire to investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Hugo Schuck, Director of Aero Research, Dept. 470C.

Honeywell

AERONAUTICAL DIVISION

2600 Ridgway Road,
Minneapolis 13, Minnesota

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H.K. Eckstrom, Honeywell, Minneapolis 8, Minn.

Numerical Listing of Exhibitors

(Continued from page 454A)

1501–1503	Librascope, Incorporated
1502–1504	Andrew Corporation
1505	GPL Div., General Precision, Inc.
1506	Licon Switch & Control Division Illinois Tool Works
1507	Link Aviation Div. of General Precision Inc.
1508–1510	Alden Products Co.
1509–1511	Kearfott Company, Inc.
1512	Alden Elect. & Impulse Recording Eq. Co.
1513	Bowmar Instrument Corp.
1514	Alfax Paper and Engineering Co.
1515	Elco Corp.
1516	Phaostron Instrument & Electronic Co.
1517	Glasseal Products Co., Inc.
1518	Maurey Instrument Corp.
1519–1519A	Curtiss-Wright Corp., Electronics Div.
1519B	Solid State Products, Inc.
1520	E.M.I.-Cossor Electronics Ltd.
1521–1525	Thompson Ramo Wooldridge Inc.
1522	International Electronic Research Corp.
1524	Automatic Metal Products Corp.
1600	Stepper Motors Corp.
1601–1607	Westinghouse Electric Corp.
1602–1608	Radio Corporation of America Electron Tube Div.
1609–1615	Hughes Aircraft Co.
1610–1618	Litton Industries, Inc.
1617	Tower Construction Co.
1619–1621	Bourns, Inc.
1620	M. Ten Bosch, Inc.
1622	JFD Electronics Corp.
1623	Audio Development Co.
1624	McLean Engineering Labs.
1625	Pic Design Corp.
1626	Ortho Filter Corp.
1627	C & K Components Inc.
1627A	The Hart Manufacturing Co.
1627B	United Mineral & Chemical Corp.
1628	Industro Transistor Corp.
1629–1631	Thompson Ramo Wooldridge, Inc.
1630	Sinclair Radio Labs. Limited
1632	Electro-Voice, Inc.
1633	Alfred Electronics
1701–1707	Radio Corporation of America Electron Tube Div.
1702	Heath Co. Div. of Daystrom, Inc.
1704–1706	Daystrom Pacific Div. of Daystrom, Inc.
1708–1710	Daystrom Inc. Weston Instruments
1709–1717	Litton Industries, Inc.
1712–1714	Wind Turbine Co.
1716–1718	Alford Manufacturing Co., Inc.
1719–1721	Bulova Res. & Dev. Labs., Inc. Bulova Watch Co.
1720–1722	Gabriel Electronics Div., The Gabriel Co.
1723	Sanders Associates Inc.
1724	Ceramaseal, Inc.
1725	Deltime, Inc.
1726A	General Time Corp.
1726B	Schutter Microwave Corp.
1727	Hetherington Switch Div., Controls Co. of America
1727A–1727B	Electrosnap Switch Div., Controls Co. of America
1728A	Consolidated Avionics Corp.

(Continued on page 457A)

- **OPPORTUNITY** to be a part of a growing company
- **FACILITIES** and equipment to carry out the job
- **RECOGNITION** for your accomplishments
- **COMPENSATION** for your achievements
- **SECURITY** with a progressive well established company

ELECTRONICS PROJECT ENGINEER

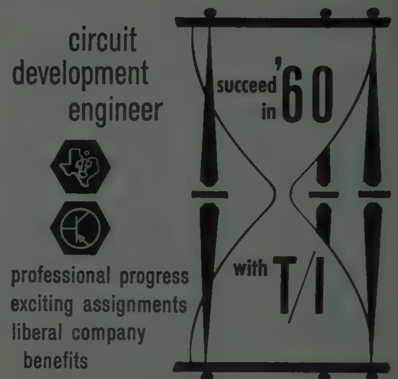
Experience should include circuit design, video techniques, r-f design, pulse techniques and similar activities.

PHOTOSURFACE PHYSICIST

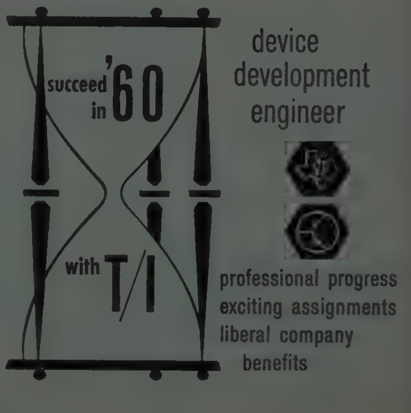
Well grounded in development, formation and measurement of photosensitive surfaces. Background should include high vacuum technique, tube design, electron optics and associated skills.

Please send resume to:

General Manager
Diamond Electronics
Div. of Diamond Power Specialty Corp.
Box 415, Lancaster, Ohio



see full-page ad page 395A



Numerical Listing of Exhibitors

(Continued from page 456A)

1728B Consolidated Diesel Electric Corp.
1729 The Thomas & Betts Co., Inc.
1730 Sarkes Tarzian, Inc.
1731 Varo Mfg. Co., Inc.
1801–1803 Heath Co., Div. of Daystrom, Inc.
1802–1804 Jennings Radio Mfg. Corp.
1805 Daystrom Transcoil, Div. of Daystrom, Inc.
1806–1808 Industrial Timer Corporation
1807–1809 Daystrom Inc.
Weston Instruments
1810 Budd-Stanley Co., Inc.
1811–1813 Ace Electronics Associates, Inc.
1812–1814 Filtron Co., Inc.
1815 Mitronics, Inc.
1816 Del Electronics Corp.
1817 The Bristol Co.
1818 Electronic Specialty Co., Technicraft Division
1819–1823 The Singer Manufacturing Co., Military Products Division
HRB-Singer, Inc.
1820 British Radio Electronics Ltd.
1822 The Walkirt Co.
1824 Twin Lock, Incorporated
1825 Harrison Laboratories, Inc.
1900 Telemeter Magnetics, Inc.
1901 Sonotone Corp.
1902 Control Electronics Co., Inc.
1903 Hill Electronics, Inc.
1904 General Magnetic Corp.
1905 Filmohm Corp.
1906–1908 Automatic Electric Sales Corp.
1907–1909 Spectrol Electronics Corp.
1910 Sage Laboratories, Inc.
1911 Keystone Products Co.
1912 National Cash Register Co., Electronics Div.
1913 Minnesota Mining & Mfg. Co.
Magnetic Products Div.
1914 Power Sources, Inc.
1915 Vemaline Products Co.
1916 G-L Electronics Co., Inc.
1917 Dyna-Empire, Inc.
1918 Aladdin Electronics Div.
Aladdin Industries, Inc.
1919 The Torrington Manufacturing Co.
1920–1924 Hoffman Electronics Corp., Semiconductor Div.
1921 Sangamo Electric Co.
1923 Branson Corp.
1925 Walter Kidde & Company, Inc.
1926 Reon Resistor Corp.
1927 American Electronics, Inc.
1928 Columbus Electronics Corp.
1929 Electro Tec Corp.
1930 Deluxe Coils, Inc.

FIRST MEZZANINE

M-1 Aetna Electronics Corporation
M-2 Guidance Controls Corp.
M-3 Methode Manufacturing Corp.
M-4 The Pyle-National Co.
M-5 Slip Ring Co. of America

(Continued on page 458A)

First Aid Room

A nurse is in charge at all times. First aid room is located on the first floor mezzanine, northwest corner of the first floor. Take elevator 20.

RESEARCH AND DEVELOPMENT ENGINEERS

Interested in **— DIRECT CONVERSION OF HEAT INTO ELECTRICITY**

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For the past several years THERMO ELECTRON ENGINEERING CORPORATION has been engaged in the research and development of thermionic converters and magnetohydrodynamic systems. Because of greatly increased activity on these advanced projects, we are pleased to announce the following immediate openings:

MECHANICAL ENGINEER — SENIOR

General ability in light mechanical devices. Able to design jigs, fixtures and mechanisms for research work. At least five years experience. Broad knowledge of vacuum tube technology highly desirable. Work to be accomplished in the research laboratory with technical personnel directly involved in experiments.

MECHANICAL ENGINEER — PROJECT LEADER LEVEL

To direct and coordinate research projects. Broad experience in vacuum tube technology necessary. Must have administrative or supervisory experience. Experience with metal or ceramic vacuum tubes highly desirable.

MECHANICAL ENGINEER, M.S. LEVEL OR EQUIVALENT

To design advanced systems utilizing direct conversion schemes. Must have analytical experience in heat transfer and strength of materials. Experience in high temperature applications desirable. Work includes preliminary design through to final prototype analysis.

COMBUSTION ENGINEER

To design and build small, high temperature combustion chambers and burner mechanisms to operate under extreme environmental conditions of ambient temperature. Five years experience and broad technical background in combustion desired.

ELECTRICAL ENGINEER

To design, execute and interpret experiments in vacuum tubes. Ability to design and build electronic circuits for measuring very small currents necessary. Broad experience in vacuum tube technology and preference for experimental work highly desirable.

PHYSICS MAJOR, M.S. LEVEL OR EQUIVALENT

To perform theoretical analysis and associated experiments in electron and ion dynamics. Broad experience in field of vacuum technology and familiarity with metallurgy and materials in vacuum tube technology highly desirable.

●

In each case, salary is commensurate with education and experience. To arrange for an interview, please submit a resume to Lawrence T. Sullivan, Business Manager at the address indicated below:

THERMO ELECTRON
ENGINEERING CORPORATION
171 HARVEY STREET • CAMBRIDGE, MASSACHUSETTS
Leaders and Pioneers in Direct Energy Conversion

Numerical Listing of Exhibitors

(*Continued from page 457A*)

M-6	Renbrandt, Inc.
M-7	Faradyne Electronics Corp., Affil. Mansol Ceramics
M-8	Tempo Instrument Incorporated
M-9	Antenna & Radome Research Assoc.
M-10	Syntron Company
M-11	Universal Electronics Co.
M-12	Pesco Products Division Borg-Warner Corporation
M-13	Nothelfer Winding Laboratories, Inc.
M-14	Tru-Connector Corp.
M-15	Babcock Relays, Inc.
M-16	Master Specialties Co.
M-17	Hoyt Electrical Instrument Works, Inc.
M-18	Chicago Dynamic Industries, Inc., Precision Products Division
M-19	Lindberg Engineering Co., High Frequency Division
M-20	Ecco Electronic Corp.
M-21	Pittman Electrical Developments Co.
M-22	Security Devices Lab., Div. Sargent & Greenleaf, Inc.
M-23	Chicago Aerial Industries, Inc., Kintronic Division
M-24	D & R Ltd.
M-25	Granite State Machine Co., Inc.

G.D.S. — to IRE engineers and engineering managers

George D. Sandel and Associates, management consultants, has been retained by one of its clients, a nationally known and respected electronics organization, to conduct a stepped-up search for engineers, scientists, and managers. A whole new order of effort is being exerted on behalf of this scientifically important client.

The current needs of this organization are most urgent in the fields of radar, information handling, missile guidance and data computation and reduction, and transmitters. Positions are open for electrical and mechanical engineers, physicists and mathematicians in development, design, specifications, packaging, project and systems engineering. There is a particular need for managers and senior engineers and scientists.

There are no limits to your opportunity for acquiring added responsibility. Assignments challenge the most ambitious and creative minds. Starting salaries are excellent.

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Management/Personnel Consultants
150 TREMONT STREET, BOSTON 11, MASS. HAncock 6-8460

SECOND FLOOR

Room 319	Electronic Representatives Assn.
2001	Gray & Kuhn, Inc., Div. of IMC Magnetics Corp.
2002	Camblock Corp., Div. Willor Mfg. Corp.
2003	Knapic Electro-Physics, Inc.
2004	Sony Corporation
2005	Moeller Instrument Company, Inc., Electronics Div.
2006	Murata Mfg. Co. Ltd., International Div.
2007	National Semiconductor Corp.
2008	Microwave Electronic Tube Co., Inc.
2009	North American Electronics, Inc.
2100	James Electronics, Inc.
2101–2103	Microdot, Inc.
2102	LEL, Inc.
2104	Power Designs, Inc.
2105	G-M Laboratories, Inc.
2106	Instrument Development Labs., Inc.
2108	Analogue Controls, Inc.
2109	Carter Parts Co.
2110–2118	Engelhard Industries, Inc.
2113	La Pointe Industries, Inc.
2115–2117	Bogue Electric Mfg. Co.
2119	George Ulanet Co.
2120	Tech Laboratories, Inc.
2121–2123	Winchester Electronics, Inc.
2122–2124	Union Switch & Signal Div., Westinghouse Air Brake Co.
2125	North Electric Co.
2126	G-C Electronics Mfg. Co.
2127	Yardney Electric Corp.
2128	Telecomputing Corp.
2129	The Gudeman Co.
2130	Electralab Printed Electronics Corp.
2130A	Rowan Controller Co.
2131	Lord Manufacturing Co.
2132–2133	Eastern Industries, Inc.
2134	Kurman Electric Co., Subs. of Crescent Petroleum Corp.
2201–2203	Photocircuits Corp.
2202–2214	Minneapolis-Honeywell Regulator Co.
2205–2207	The U.S. Stoneware Co., Alite Div.
2209	Vari-L Company, Inc.
2211	Drake Manufacturing Co.
2213–2215	Electronic Measurements Co., Inc.
2216	Southern Electronics Corporation
2217	Gremar Manufacturing Co., Inc.
2218–2220	C. P. Clare & Co.
2219	Cambridge Thermionic Corp.
2221–2225	Simpson Electric Company
2222–2232	Bendix Aviation Corp. Scintilla Division Red Bank Div. Bendix-Pacific Div. Montrose Div. Eclipse-Pioneer Division Semiconductor Products
2227	Hi-G, Inc.
2229	IMC Magnetics Corp.
2231	Ward Leonard Electric Co.
2233	Elgin National Watch Co., Advance Relays Division
2234	The Victoreen Instrument Co.
2235	Pyrofilm Resistor Co., Inc.
2236	Sage Electronics Corp.
2237	James Cunningham Son & Co., Inc.
2238	The Ericsson Corp.
2239	Epco Products, Inc.
2240	Condenser Products Div., New Haven Clock and Watch Co.
2241–2243	Douglas Microwave Co., Inc.
2242–2244	Barber-Colman Co.
2301–2303	Microwave Associates, Inc.
2302–2304	Vitramon, Inc.

(*Continued on page 460A*)

Something significant has been added to career potential at **STROMBERG-CARLSON**

Positions immediately available
on both Commercial and Defense Projects:

This **something significant** is the increased emphasis on inter-divisional engineering programming between the 7 different Divisions of General Dynamics, of which Stromberg-Carlson is the Electronics Arm.

Pooling of knowledge in diverse fields of endeavor greatly enlarges the professional scope of the individual engineer. For instance, three divisions of the corporation are deeply involved in Anti-Submarine Warfare work: Stromberg-Carlson, Electric Boat and Convair (as well as General Dynamics' Canadian subsidiary, Canadair, Ltd.). In this endeavor all make use of research findings developed with the aid of Stromberg-Carlson's new sonar test facility in Rochester, N. Y. This is the nation's largest indoor, underwater acoustic facility.

Take other areas of special interest to Stromberg-Carlson engineers: Instrumentation and safety systems for nuclear reactors and ground testing equipment for missile systems. Here interchange of information with General Atomics, Electric Boat and Convair Divisions adds a new dimension to Stromberg-Carlson's electronics capability.

Long a solidly established growth company, Stromberg-Carlson can also add another plus value to its long-term opportunities for engineers—the financial strength of the large and diversified parent, General Dynamics Corporation.

RESEARCH SCIENTISTS

Advanced degree EE's and Physicists to handle conceptual studies in areas of solid state circuitry and semi-conductors; molecular electronics; hydro-acoustics; digital data transmission; and speech analysis. Also openings for advanced degree mathematicians for study projects in information theory and related areas.

DEVELOPMENT ENGINEERS

Current openings at intermediate through technical supervisory levels for men experienced in global and inter-global communications systems; microwave circuit design; digital handling and display equipment; doppler radar; and air navigation control instrumentation.

CONSUMER PRODUCT DESIGN ENGINEERS

Intermediate to senior level openings for engineers to work on stereo, hi-fi, auto radio and commercial sound systems, with experience in audio and R. F. field utilizing transistorized circuitry. Also openings for engineers experienced in design of special switching and electro-mechanical circuitry for telephone systems.

Also positions for:

Field Service Engineers; Production Test Engineers; Test Equipment Design Engineers; Military Sales Engineers.

**If you are interested in and qualified for one of these positions, send a complete resume to Robert L. Ford, Manager of Technical Personnel*

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
1476 N. Goodman St., Rochester 3, New York

Numerical Listing of Exhibitors

(Continued from page 458A)

2305 Tru-Ohm Products Div.
Model Engineering & Mfg., Inc.
2306–2308 Airpax Electronics Incorporated
2307–2309 Continental Connector Corp.
De Jur-Amsco Corp.
2310 Illinois Condenser Co.
2311 Mc Coy Electronics Co.
2312 Electro-Mec Laboratory, Inc.
2313 Curtis Development & Mfg. Co.
2314–2316 Allen-Bradley Co.
2315 Microtran Co., Inc.
2317–2319 Technology Instrument Corp.
2318–2320 Lambda Electronics Corp.
2321–2323 American Television & Radio Co.
2322–2332 Sylvania Electric Products, Inc.
2325 Herman H. Smith, Inc.
2327 Stevens Mfg. Co., Inc.
2329–2331 M. C. Jones Electronic Co., Inc., Sub. Bendix Aviation Corp.
2333–2335 Ohmite Manufacturing Co.
2334–2336 Corning Glass Works
2337 Donald P. Mossman, Inc.
2338 Federal Pacific Elec. Co., Fifty Avenue L Div.
2339 Bogart Manufacturing Corp.
2340 Phillips Control Corp.
2341 Buchanan Electrical Prods. Corp.
2342–2344 John Gombos Co., Inc.
2343 A'G'A Division, Elastic Stop Nut Corp. of America
2401–2405 Union Carbide Consumer Products Co., Div. of Union Carbide Corp.
Kemet Co., Div. Union Carbide Corp.
2402–2408 Amphenol-Borg Electronics Corp.
Borg Equip. Div.
Industrial Prods—Danbury Knudsen
Amphenol Connector Corp.
Amphenol Cable & Wire Div.
Amphenol Pacific Div.
2407 Microwave Development Labs., Inc.
2409 Price Electric Corp.
2410–2412 Eitel-McCullough, Inc.
2413–2414 United Transformer Corp.
2415–2425 Sylvania Electric Products, Inc.
2416–2424 Sprague Electric Co.
2426 The Triplett Electrical Instrument Co.
2427–2429 Corning Glass Works
2428–2430 Tung-Sol Electric, Inc.
2431 Balco Research Laboratories, Inc.
2432 Sperry Electronic Tube Div., Sperry Rand Corp.
2433 Dage Electric Co., Inc.
2434 Sperry Semiconductor Div., Sperry Rand Corp.
2435 Lieco, Inc.
2436 Sperry Gyroscope Co., Div. of Sperry Rand Corp.
2437 Magnetics, Inc.
2438 Sperry Microwave Electronics Co., Div. Sperry Rand Corp.
2501–2507 Amphenol-Borg Electronics Corp.
2502–2504 Guardian Electric Mfg. Co.
2506–2508 Robinson Technical Products, Inc.
2509–2515 The Arnold Engineering Co.

Be sure to
see all four floors!

2510–2520 International Telephone & Telegraph Corp.
Federal Electric Corp.
ITT Components Div.
ITT Federal Div.
ITT Industrial Prods. Div.
ITT Laboratories
International Electric Corp.
Kellogg Switchboard & Supply Co.
2517 James Millen Mfg. Co., Inc.
2519 Audio Devices, Inc.
2521–2523 Tung-Sol Electric, Inc.
2522–2524 Amperex Electronic Corp.
2525 Magnecraft Electric Co.
2526–2528 Electrical Industries, Div. Philips Electronics, Inc.
2527–2531 AMP Incorporated
Capitron Div., AMP, Inc.
2530 Ferroxcube Corp. of America
2532 D. S. Kennedy & Co.
2533 Magnetics, Inc.
2534 Barry Controls Incorporated
2535–2536 Cinch Mfg. Corp.
Howard B. Jones Div., Cinch Mfg. Corp.
United-Carr Fastener Corp.
2601 Air-Marine Motors, Inc.
2602 Astron Corp.
2603–2607 Aerovox Corporation
2604–2614 Raytheon Company
Machlett Laboratories, Inc.
Sorensen & Co., Inc.
2615–2625 International Telephone & Telegraph Corp.
2616–2626 Clevite Corp.
Brush Insts. Div.
Clevite Electronic Components
Clevite Transistor Products
2627–2629 Dale Products, Inc.
2628–2632 Cannon Electric Company
2631 Gorham Electronics Div., Gorham Mfg. Co.
2633 Globe Industries, Inc.
2634 Shallcross Mfg. Co.
2635 San Fernando Electric Mfg. Co.
2636–2638 Kepco, Inc.
2637 D. S. Kennedy & Co.
2701–2707 Fairchild Camera & Instrument Corp.
Fairchild Controls Corp.
Fairchild Semiconductor Corp.
2702–2704 Potter & Brumfield, Inc., Div. American Machine & Foundry
2706 Belling & Lee Limited
Ercona Corp.
2708 The James Knights Co.
2709 Behlman Engineering Co.
2710–2712 Bomac Laboratories, Div. Varian Associates
2711 Syntronic Instruments, Inc.
2713–2715 U.S. Semiconductor Products, Div. United Industrial Corp.
2714–2720 Varian Associates
2717–2719 The Daven Company
2721–2723 Freed Transformer Co., Inc.
2722–2732 The Superior Electric Co.
2725–2727 Cornell-Dubilier Electric Corp., Affil. Federal Pacific Electric Co.
2729–2731 Mycalex Corp. of America
2733–2735 Sigma Instruments, Inc.
2734 The Electro Motive Mfg. Co., Inc.
2736 The Capitol Machine Co.
2737 Bussmann Mfg. Division, McGraw-Edison Co.
2738 RS Electronics Corp.
2739–2741 Thomas A. Edison Industries, Instrument Div.
2740 Plastic Capacitors, Inc.
2742–2744 Pacific Semiconductor, Inc.
2743 Good-All Electric Mfg. Co.
2801 Grayhill, Inc.
2802–2804 Mepco, Inc.
2803 Penta Laboratories, Inc.
2805 U.S. Components, Inc.
2806 Burgess Battery Co.
2807 Mucon Corp.
2808 Filtors, Inc.
2809–2811 Communication Accessories Co., Subsidiary of Collins Radio Co.
2810 Hardwick, Hindle, Inc.
2812 Servomechanisms, Inc., Mechatrol Div.
2813 International Instruments, Inc.
2814–2816 Garlock Electronic Products, The Garlock Packing Co.
2815–2819 Sola Electric Co., Div. Basic Products Corp.
2818 ERA Electric Corp.
2820 Electronic Research Assoc., Inc.
2821–2823 Kings Electronics Co., Inc.
2822–2826 International Resistance Co.
2825 Kemtron Electron Products, Inc.
2827 Switchcraft, Inc.
2828 Perkin-Elmer Corp., Vernistat Div.
2829–2831 Dialight Corp.
2830–2832 Rotron Mfg. Co.
2833 J-B-T Instruments, Inc.
2834–2836 Electra Manufacturing Co.
2835 All Products Co.
2837 Industrial Electronic Hardware Corp.
2838 The Gamewell Co., Potentiometer Div.
2839 Polyphase Instrument Co.
2840 Bergen Laboratories
2841–2843 Heinemann Electric Co.
2842 Bradley Semiconductor Corp.
2844 Northeast Scientific Corp.
2900 Kulka Electric Corp.
2901–2903 International Rectifier Corp.
2904–2932 General Electric Co.
2904 General Electric Co., Semiconductor Products Dept.
2905–2907 Allied Control Co., Inc.
2906–2908 General Electric Co., Receiving Tube Dept.
2909–2910 Burnell & Co., Inc.
2911 Christie Electric Corp.
2912–2914 General Electric Co., Power Tube Dept.
2913 Thomas Electronics, Inc.
2914 General Electric Co., Laminated Products Dept.
2915 ESC Corporation
2916 General Electric Co., Large Lamp Dept.
2917–2918 Huggins Laboratories, Inc.
2919 Telex, Inc.
2920 General Electric Co., Missile and Space Vehicle Dept.
General Electric Co., Magnetic Materials Section
2921 Oak Manufacturing Co.
2922 Sealectro Corp.
2923 Littelfuse, Inc.
2924 General Electric Co., Heavy Military Electronics Dept., Voltage Regulator Section
General Electric Co., Power Transformer Dept.
2925–2926 Rheem Semiconductor Corp.
2927 Comar Electric Co.
2928 General Electric Co., Capacitor Dept.
General Electric Co., Specialty Control Dept.
General Electric Co., Instrument Dept.
2929 Thomas & Skinner, Inc.
2930–2931 The Carborundum Co.
2932 General Electric Co., Industrial Heating Dept.
General Electric Co., Silicone Products Dept.
2933 Richard Hirschmann Radio Tecnisches Werk, Rye Sound Corp.
2934 Stevens-Arnold, Inc.
2935 Dempa Shinbun, Inc.
Japan Electric, Toko Coil Labs., Tokyo Shibaura Electric Co., Ltd.
2937 Shepherd Industries, Inc.

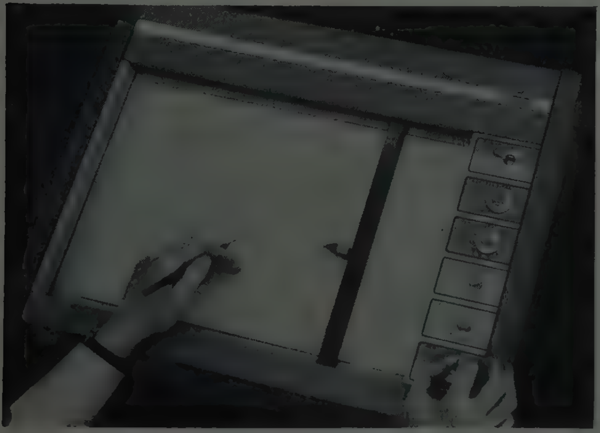
(Continued on page 462A)

HOW DO YOU TEST AN X-Y PLOTTER

In an automobile, transmissions can be designed to give top speeds by sacrificing acceleration—but it's a poor bargain, as a quick road test will show. Similarly, in an X-Y analog plotter high slewing speeds can be obtained by sacrificing acceleration. Again it's a poor bargain because highest plotting accuracy depends upon high static accuracy combined with a *perfect balance between acceleration and velocity limits.* EAI's Model 1100E Variplotter has this desired balance as a simple 'road test' developed by EAI engineers can graphically demonstrate.

As a matter of fact, everything about the Model 1100E Variplotter has been engineered to give you the utmost in plotting performance. Developed to speed up engineering control, testing and design operations, it consistently produces faster, more accurate plots of X-Y related data.

The development of the Model 1100E has resulted from EAI's years of pioneering research and development in the field of automatic plotting. It provides outstanding accuracy of 0.075% F.S. — less than the width of the line drawn by the pen. Arm acceleration is 250 inches/sec.². Pen acceleration is 750 inches/sec.². The high velocity of the 1100E is augmented by this faster acceleration to assure outstanding dynamic performance.



Repeated testing under actual operating conditions proves that the principle of the Variplotter, Model 1100E design virtually eliminates backlash, and provides drift-free operation for periods of 8 hours or more. This superior repeatability has been amply testified by users who report that even after overnight shut-down, the Model 1100E resumes plotting with no noticeable drift.

A complete line of accessories—including bi-variant function generator, digital data plotting (manual or automatic) and time base generator—makes the EAI Variplotter the most versatile automatic plotting method available. The Model 1100E can be easily converted to operate as a function generator—or will plot digital information manually from a keyboard as well as automatically from punched cards or paper tape—by simple addition of compatible components.

Check these features...
- Portable desk-top size—
- Large plotting surface (11" x 17")—
- Vacuum hold down—
- High dynamic and static accuracy—
- Rugged construction—
- Ease of maintenance—
- Differential input—
- Plug-in input network—
- Superior repeatability.

Ask your EAI representative to show you the simple laboratory test that proves the superiority of the Model 1100E Variplotter,—or write for Bulletin AP 810-1.

See Model 1100E Variplotter in operation, N.Y. IRE, Booths 3712-18.

EAI

ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

Now

A NEW 50 VOLT SUBMINIATURE PAPER CAPACITOR

meets requirements of MIL-C-25A K characteristic

FOR TRANSISTORIZED APPLICATIONS

Astron's new 50 volt hermetically sealed subminiature paper capacitors have the reliability required by specification MIL-C-25A. These units operate at temperatures from −60°C to +125°C without derating. The capacitance variation is less than ±3% over the entire operating temperature range. High insulation resistance, low power factor, unusually low resonance loss are combined in this new light-weight, subminiature unit.

Write today for complete technical information.

PARTIAL LIST OF RATINGS AVAILABLE

TYPE AQF
ASTRON

CAP. MF	DIA. x LENGTH
0.027	.235 x 3/4
0.068	.312 x 7/8
0.1	.312 x 7/8
0.27	.400 x 1-3/8
0.47	.500 x 1-1/4
1.0	.562 x 1-5/8
2.0	.750 x 2-1/8

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TORONTO CANADA

See us at IRE Show Booth 2602

Numerical Listing of Exhibitors

(Continued from page 460A)

THIRD FLOOR

3000	Rohde & Schwarz Sales Co. (U.S.A.) Inc.
3001–3002	Veeco Vacuum Corporation
3003	Levinthal Electronic Prods. Inc.
3004	Radiation, Inc.
3005	Radar Measurements Corp.
3006	Wallson Associates, Inc.
3007	Strand Labs., Inc.
3008	Blue M Electric Company
3009	Mid-Eastern Electronics, Inc.
3010–3011	Electro-Measurements, Inc.
3012	Landis & Gyr, Inc Sodeco
3013	Foto-Video Laboratories, Inc.
3014	Instron Engineering Co.
3015	Sierra Research Corporation
3016	Optimized Devices, Inc.
3017	Magnetic Instruments Co., Inc., Sub. Pyrometer Co. America, Inc.
3018	ELIN Division, International Electronic Research Corp.
3019–3020	Dymec, Div. of Hewlett-Packard Co.
3021	The Standard Electric Time Corp.
3022	Telonic Industries, Inc.
3023	North Hills Electric Co., Inc.
3024	Pitometer Log Corp.
3025	EH Research Laboratories, Inc.
3026	General Resistance, Inc.
3027–3030	Tektronix, Inc.
3031–3032	Sierra Electronic Corp.
3033	Trio Laboratories, Inc.
3034	Quan-Tech Laboratories
3035	Precision Instrument Company
3036	Barnes Engineering Co.
3037	Precise Development Corp.
3038–3039	Hermes Electronic Co.
3041–3042	Non-Linear Systems, Inc.
3043	Temco Aircraft Corp., Electronics Div.
3044	Pickard & Burns, Inc.
3045	Di/An Controls, Inc.
3051	Offner Electronics, Inc.
3052	Burr-Brown Research Corp.
3053	Itemco, Inc.
3054	Yokogawa Electric Works, Inc.
3056	Jerrold Electronics Corp.
3059	Lumatron Electronics, Inc.
3060	General Dynamics Corp., Liquid Carbonic Div.
3061–3062	Shielding, Inc.
3063	CBS Laboratories, Div. Columbia Broadcasting System, Inc.
3064	Avco Corporation, Crosley Division
3065	Avco Corporation, Research & Adv. Development Div.
3101–3102	Boonton Radio Corp.
3103–3104	Computer-Measurements Corp.
3105–3106	Waterman Products Co., Inc.
3107–3109	MB Electronics
3108	Northeastern Engineering, Inc.
3110	Cook Electric Co., Data-Stor Div.
3111	Philamon Labs., Inc.
3112–3113	Electronic Tube Corp.
3114	Boonton Electronics Corp.
3115–3119	Radio Frequency Laboratories, Inc.
3116–3118	Probescope Company
3120	Dynapar Corporation
3121	Larson Instrument Co.
3122	Precision Scientific Co.

(Continued on page 464A)

MICROWAVE CAVITIES

NEW

Here is a cavity, designed for microwave link application, which replaces a unit costing four times as much. Shown are glass seal tunable cavities for use with microwave discriminators. Some of their outstanding characteristics are:

1. Tuning range 5925-6425 mc
6575-6875 mc
7125-7750 mc
2. Temperature stability ± 2 mc for −20° to +70°C.
3. No change with humidity.
4. Can withstand severe vibration and shock.
5. Loaded Q = 250.

This unit along with its accompanying discriminator, can be made available in all waveguide sizes from L through Ka band.

PORTCHESTER INSTRUMENT CORP.
114 WILKINS AVE. PORTCHESTER, N.Y.

IF YOU NEED ELECTRONIC TUBES... YOU NEED WESTINGHOUSE!

For microwave / Welding / RF Generation

Atomic Energy / Shaker Tables / Power Amplifiers

Sonar / Communications / Camera Tubes / Memory Tubes

Special Purpose CRT / Radio / Hi Fi / Television

(Just name the job! Westinghouse tubes can be supplied from stock or on special order for any application, in any quantity you require!)

YOU CAN BE SURE...IF IT'S

Westinghouse

Westinghouse Electronic Tube Division, Elmira, N. Y.

be sure to visit

BOOTH 1408 AT THE IRE SHOW

for everything new and important in tube design!

Numerical Listing of Exhibitors

(Continued from page 462A)

3123 B & F Instruments, Inc.
3201–3208 General Radio Co.
3205–3209 Polarad Electronics Corp.
3210–3212 F. L. Moseley Co.
3211 Telewave Laboratories, Inc.
3213 Manson Laboratories, Inc.
3214 Bogen-Presto Company, Div. of Siegler Corp.
3215–3217 Bird Electronic Corp.
3216–3218 De Mornay-Bonardi
3219–3221 Baird-Atomic
3220 Herman H. Sticht Co., Inc.
3222 Waveforms, Inc.
3223 Navigation Computer Corp.
3224 Wang Laboratories, Inc.
3225 Blonder-Tongue Laboratories, Inc.
3226–3228 Tenney Engineers, Inc.
3227–3229 Industrial Instruments, Inc.
3230 Muirhead Instruments, Inc.
3231–3233 Antlab, Inc.
3232 Wayne-George Corp.
3234 Datex Corp.
3235 Cubic Corp.
3236 Harvey-Wells Electronics, Inc.
3237 Mc Millan Laboratory, Inc.
3238 Julie Research Laboratories
3239 International Radiant Corp.
3240 The Geotechnical Corp.
3241 Telectro Industries Corp.
3242 John Fluke Mfg. Co., Inc.
3243 Erie Resistor Corp.
3244 Genisco, Incorporated
3301–3305 Marconi Instruments
3302–3306 Hewlett-Packard Co.
3307–3309 Southwestern Industrial Electronics Co., Div. Dresser Inds.
3308–3310 Computer Control Company, Inc.
3311 Electron Corp., Div. Ling-Altec Electronics, Inc.
3312–3314 Crosby-Teletronics Corp.
3313 Rawson Electrical Instr. Co.
3315–3317 Panoramic Radio Products, Inc.
3316–3318 Airborne Instruments Lab., Div. Cutler-Hammer, Inc.
3401–3405 Hewlett-Packard Co.
3402–3404 Ballantine Laboratories, Inc.
3406–3408 British Industries Corp.
3407–3409 Potter Instrument Co., Inc.
3410–3412 Sensitive Research Instrument Corp.
3411 Rixon Electronics, Inc.
3413–3417 Airborne Instruments Lab., Div. Cutler-Hammer, Inc.
3414 Specific Products
3416–3418 Beckman Instruments, Inc., Berkeley Div.
3501–3503 Measurements, A McGraw-Edison Division
3502–3508 Collins Radio Co.
3505 Electronic Instrument Co., Inc. EICO
3507–3511 International Business Machines Corp.
3510 Northern Radio Co., Inc.
3512–3518 Kay Electric Co.
3513 Industrial Test Equipment Co.
3515–3517 Gates Radio Co.
3601–3605 Sanborn Co.
3602–3606 Polytechnic Research & Dev. Co., Inc., Div. Harris Intertype
3607 Millivac Instruments, Div. Cohu Electronics, Inc.
3608–3610 Century Electronics & Instruments, Inc.
3609–3611 Massa Labs., Div. Cohu Electronics, Inc.
3612–3614 Telechrome Mfg. Corp.
3613–3617 KinTel Division, Cohu Electronics, Inc.
3616–3618 The Hickok Electrical Instrument Co.
3701–3703 Gertsch Products, Inc.
3702–3706 The Technical Materiel Corp.
3705 Ad-Yu Electronics Lab., Inc.
3707–3709 Packard-Bell Electronics Corp., Technical Prods. Div.
3708–3710 Krohn-Hite Corp.
3711 MacLeod & Hanopol, Inc.
3712–3718 Electronic Associates, Inc.
3713–3717 FXR, Inc.
3801 Ferris Instrument Co.
3802–3804 Ling Electronics, Div. Ling-Altec Electronics, Inc.
3803–3805 CGS Laboratories, Inc.
3806–3808 Servo Corporation of America
3807 Hastings-Raydist, Inc.
3809 Precision Apparatus Co., Inc.
3810–3812 Electro-Pulse, Inc.
3811 Systron Corporation
3813 The Narda Microwave Corp., HPED Division
3814–3816 Burlingame Associates
3815–3817 The Narda Microwave Corp.
3818–3820 Empire Devices Products Corp.
3819–3821 Laboratory for Electronics, Inc.
3822–3824 Bell Aircraft Corp., Avionics Division
3823 Beattie-Coleman, Inc.
3825 Victor Adding Machine Co.
3826–3828 Nems-Clarke Co., Div. Vitro Corp. of America
3827–3829 Wayne Kerr Corporation
3830–3832 Associated Testing Labs., Inc.
3831 Digital Equipment Corp.
3833 North Atlantic Industries, Inc.
3834 Rutherford Electronics Co.
3835 Franklin Electronics, Inc.
3836–3838 Electro Instruments, Inc.
3837–3839 Computer Systems, Inc.
3840–3842 Acton Laboratories, Inc.
3841 The United States Time Corp.
3843 Menlo Park Engineering
3843B Frequency Standards, Inc., Div. National Electric Products Corp.
3844 Hoover Electronics Co., Subsid. The Hoover Co.
3846 Micro Gee Products, Inc.
3848 Conrad, Inc.
3901–3905 Allen B. DuMont Labs., Inc.
3904–3906 Epsco, Inc.
3907 Keithley Instruments, Inc.
3908 Veeder-Root, Inc.
3909 Scientific-Atlanta, Inc.
3910–3914 American Bosch Arma Corp.
3911–3913 Lavoie Laboratories, Inc.
3914B Edgerton, Germeshausen & Grier, Inc.
3915–3917 Knight Electronics
3916–3918 Assembly Products, Inc. Metronix Div., Assembly Prods.
3919–3921 The Martin Co.
3920–3922 California Technical Industries, Div. Textron, Inc.
3923 Minnesota Mining & Mfg. Co., Mincom Div.
3924 Greibach Instruments Corp.
3925–3927 American Machine & Foundry Co.
3926 The Garrett Corp.
3928–3930 Ace Engineering & Machine Co., Inc.
3929 Electronic Applications, Inc.
3930B San Diego Scientific Corp.
3931–3933 The Electric Hotpack Co., Inc.
3932 Page Communications Engineers, Inc., Div. Northrop Corp.
3934 Centronix, Inc.
3935 American Electronic Laboratories, Inc.

(Continued on page 466A)

HIGH POWER K_U CIRCULATOR

MODEL NO. R-129 H

FREQUENCY: 15.7 to 16.9 Kmc (2% BAND)
ISOLATION: TRANS.-REC. 20 DB
ANT.-TRANS. 20 DB
INSERTION LOSS: TRANS.-ANT. 0.5 DB
ANT.-REC. 0.5 DB
TEMP.: −40°C to +100°C
VSWR: 1.10 MAX.
POWER: 100 KW PEAK
100 WATTS AVE.
LENGTH: 3.0″
WEIGHT: LESS THAN 12 OZ.
WAVEGUIDE: MATES WITH RG-91/U

HIGH POWER K_u FERRITE SWITCH

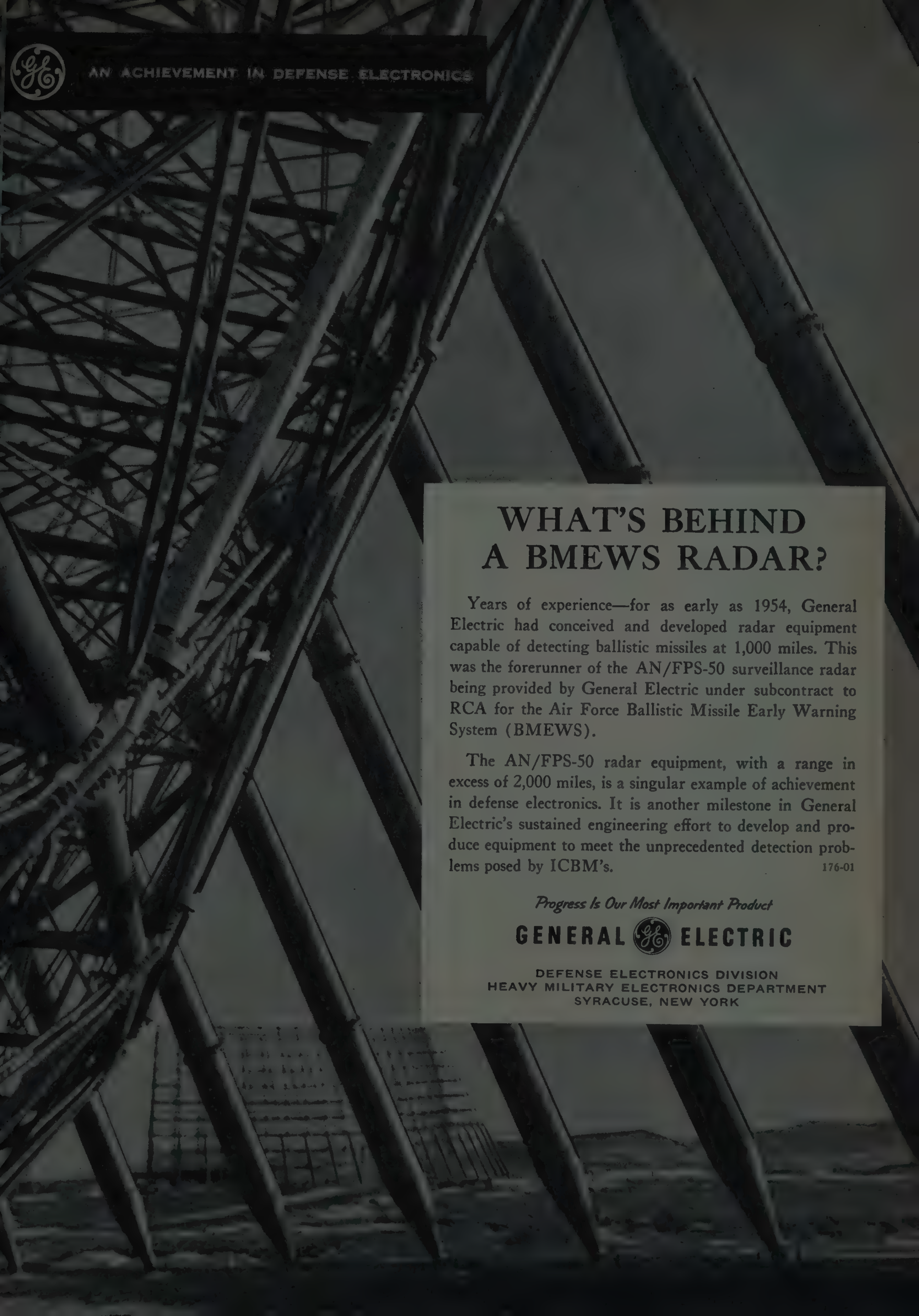
MODEL NO. R-107 H

FREQUENCY: 15.7 to 16.9 Kmc (2% BAND)
ISOLATION: TRANS.-REC. 20 DB
ANT.-TRANS. 20 DB
INSERTION LOSS: TRANS.-ANT. 0.5 DB
ANT.-REC. 0.5 DB
VSWR: 1.20 MAX.
TEMP.: −40°C to +100°C
LENGTH: 5.5″
POWER: 100 KW PK.
100 WATTS AVE.
SWITCHING TIME: 10μ sec. 90% SWITCHED
DRIVING POWER: 70 WATTS PK.
2 WATTS AVE.
WEIGHT: 1.0 lb.
WAVEGUIDE: MATES WITH RG-91/U

See us at IRE Booth 3007

Ask about our latest developments in broadband high power tee circulators.

FERROTEC, INC.
217 California Street • Newton 58, Mass. Tel. DE 2-7600



AN ACHIEVEMENT IN DEFENSE ELECTRONICS

WHAT'S BEHIND A BMEWS RADAR?

Years of experience—for as early as 1954, General Electric had conceived and developed radar equipment capable of detecting ballistic missiles at 1,000 miles. This was the forerunner of the AN/FPS-50 surveillance radar being provided by General Electric under subcontract to RCA for the Air Force Ballistic Missile Early Warning System (BMEWS).

The AN/FPS-50 radar equipment, with a range in excess of 2,000 miles, is a singular example of achievement in defense electronics. It is another milestone in General Electric's sustained engineering effort to develop and produce equipment to meet the unprecedented detection problems posed by ICBM's. 176-01

Progress Is Our Most Important Product

GENERAL ELECTRIC

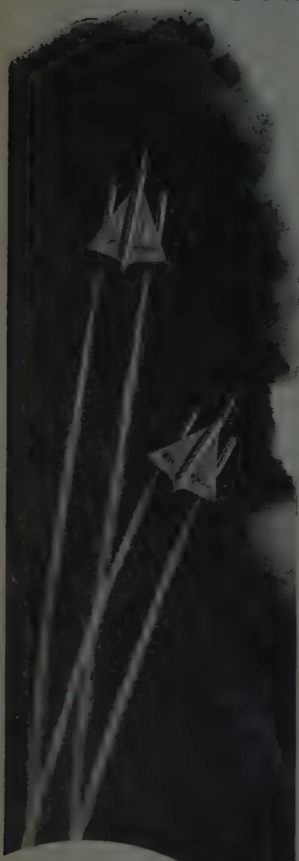
DEFENSE ELECTRONICS DIVISION
HEAVY MILITARY ELECTRONICS DEPARTMENT
SYRACUSE, NEW YORK

Airborne Time Code Generator illustrates high-density packing obtainable with T-Series circuits.

Hinged arrangement of mounting panel facilitates accessibility.

The finished package weighs only 20 lbs.; measures 5" x 8" x 20⅜". Unit generates 14-digit Point Mugu code, modulating a 1 kc carrier plus a dc time code. Three sine wave and four pulse outputs are also provided, all with only 96 T-Series circuits and 77 watts of input power.

FROM SYSTEM SPECS TO BREADBOARD TO FINISHED PRODUCT IN 75 DAYS!



That's the record set by the manufacturer of this complex airborne Time Code Generator — thanks to the compatibility of proven EECO T-Series Circuit Modules and the flexibility of the EECO Breadboard Kit.

Designed and developed for testing the fire control of manned supersonic aircraft under actual flight conditions at altitudes up to 80,000 feet, this Time Code Generator employs T-Series circuits throughout. Required accuracy of 1 part in 10^5 was easily obtained.

HIGH DENSITY, LIGHT WEIGHT

The total package contains 96 T-Series Circuits, 14 filament-type EECO Minisig Indicators, and power converters (the beginning of our line of compact 12-volt EECO Power supplies for use with T-Series circuits) — all within a volume of ½ cubic foot. In spite of this terrific packing density, the equipment still retains extreme ease of accessibility and weighs only 20 lbs. No cooling is required.

T-SERIES VS. VACUUM TUBE CIRCUITS

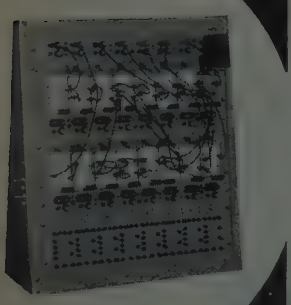
The use of T-Series transistorized Germanium circuits throughout resulted in great savings as against equivalent equipment designed around vacuum tube circuits. Here are some startling comparisons:

	T-SERIES	VACUUM TUBE
SIZE	800 cu. in.	8,000 cu. in.
WEIGHT	20 lbs. (including power converters)	160 lbs. (plus fan and power supply)
POWER	77 watts	650 watts (plus power for fan)

SAVE TIME AND MONEY

You, too, can develop the most complex equipment in record time with these proven EECO circuits and systems development aids. They'll save you time and money in four major areas:

1. **DESIGN** — You can devote full time to system design problems or unusual circuit requirements, knowing that routine circuit detail has been compatibly pre-engineered and packaged for you.
2. **BREADBOARD** — The unique EECO Breadboard Kit and plastic circuit cards enable you to set up, change, or take down experimental arrangements quickly — without waste of time or materials. Unit contains all necessary permanent wiring to accommodate any regular T-Series circuit. All other circuit inter-connections are made by patch cords or plugs, with prepunched circuit cards to guide you.
3. **PRODUCTION** — Your production problem is reduced to one of mounting sockets on panels or chassis and providing simple socket-to-socket wiring. Plug in the appropriate circuits and the system is complete.
4. **CHECKOUT**—The extreme reliability of T-Series circuits eliminates the need for circuit "debugging." Checkout time is reduced to a bare minimum.



EECO Breadboard Kit.

Why not let proven EECO T-Series circuits and systems development aids help you solve your equipment design problems?

If you have not already requested your copy of our new Catalog No. 859, write us today on your company letterhead.

ENGINEERED ELECTRONICS Company

ENGINEERED ELECTRONICS COMPANY
(a subsidiary of Electronic Engineering Company of California)
506 East First Street • Santa Ana, California

Look for us at the IRE National Convention, New York, March 21-24

Numerical Listing of Exhibitors

(Continued from page 464A)

3936	Republic Aviation Corp., Special Products and Services Div.
3937–3939	General Mills, Inc., Mechanical Div.
3938	A.R.F. Products, Inc.
3940	Electrol, Inc.
3943	James G. Biddle Co.
3944	Dynatran Electronics Corp.
3945	Virginia Electronics Co., Inc.
3946	Electronic Measurements Corp.
3947	Ebauches, S.A. Freeport Engineering Co.
3948	Zenith Radio Corp.
3949	Dytronics Co.
3950	Thermo Electron Engineering Corp.
3951	Unholtz Dickie Corp.
3952	Molectronics Corp., Div. Minneapolis-Moline Co.

FOURTH FLOOR

4001	Chassis-Trak, Inc.
4002	Utica Drop Forge & Tool
4003	Weckesser Co.
4004	Barnstead Still & Sterilizer Co.
4005–4006	Coors Porcelain Co.
4007	Wright Metalcoaters, Inc.
4008	Edwin B. Stimpson Co., Inc.
4010	Wales-Strippit, Inc.
4011	MM Enclosures, Inc.
4012	Hexacon Electric Co.
4013	Cable Designs, Inc.
4014	Raybestos-Manhattan, Inc.
4015	Little Falls Alloys, Inc.
4016	Rosan, Inc.
4017	Boston Insulated Wire & Cable Co.
4018	Rogan Brothers, Inc.
4019 & Room 610	Univeral Instruments Corp.
4020	Dynacor, Inc.
4021–4022	Fansteel Metallurgical Corp.
4023	Allegheny Electronic Chemicals Co.
4024	Weller Electric Corp.
4025	Gudebrod Bros. Silk Co., Inc.
4026–4027	Monsanto Chemical Co.
4028–4029	Phelps Dodge Copper Products Corp., Inca Mfg. Div.
4030	Jones & Lamson Machine Co.
4031	Combined Book Exhibit, Inc.
4032	Gorman Machine Corp.
4033	American Electrical Heater Co.
4034	Swiss Jewel Company Herman D. Steel Co.
4035	New Hermes Engraving Machine Corp.
4036–4037	Unistrut Products Co.
4038	Micromech Mfg. Corp., Div. of Sanford Mfg. Corp.
4039	Stewart Stamping Co.
4040	Adolf Meller Company
4041	Actioncraft Products
4042	Anchor Metal Co., Inc.
4043	Eubanks Engineering Co.
4044	The Zippertubing Co.
4045	Raytheon Co., Industrial Apparatus Div.
4046	Norrich Plastics Corp.
4047	Uniform Tubes, Inc.
4048	Howard W. Sams & Co., Inc.
4049	Optical Coating Laboratory, Inc.
4050	Furane Plastics, Inc.
4051	Vector Electronic Co.
4052	Leach & Garner Co., and General Findings & Supply Co.

(Continued on page 468A)

Timing is our forte . . .

Electronic timing devices and controls that represent the state-of-the-art in performance and reliability . . . *precision performance* that's built-in by engineering know-how; *unquestioned reliability* that's guaranteed by a comprehensive Quality Assurance Program including functional and environmental testing of *each* production unit. And we believe you'll appreciate the Tempo brand of customer service . . . from prompt, thorough handling of your special requirements to consistent, on-schedule deliveries and field service follow-thru.

TEMPO INSTRUMENT INCORPORATED
HICKSVILLE, N.Y.

SOLID STATE TIMING MODULES. Subminiature "building block" components, with accessible control points; may be used to develop a wide range of timing and programming functions. Fixed or adjustable time periods from .00005 to 300 seconds.

ELECTRONIC TIME DELAY RELAYS. No moving parts except relay contacts, 2PDT-2 amp or 3PDT-10 amp ratings; fixed or adjustable time delays from .02 to 300 seconds; accuracy to 3% or better; vibration-proof to 2,000 cps at 20 g's.

FLASHERS. Typical operation: Flashing rate of 40 cycles per minute, with a one-to-one ratio of on time to off time.

INTERVALOMETERS. Typical operation: 300 seconds after application of 28 vdc, output relay energizes; 3 seconds later, relay de-energizes. Cycle repeats itself until supply voltage is removed.

REPEAT CYCLE TIMERS. Provide multi-channel control signals, each with a timing pulse of pre-determined magnitude. Sequencing of output pulses is synchronized.

PULSE TRAIN GENERATORS. For control of various loads in a single system. Provides output signals and pulses of specified characteristics.

SEQUENCE TIMERS. Typical operation: Provides sixty-four sequential pulses each of 100 milliseconds duration, starting immediately upon application of 28 vdc. Automatically stops after last pulse.

PROGRAMMERS. Designed to suit particular system requirements. Typical unit may provide a complete timing and control program covering more than 5000 seconds from start.

IRE Show — Tempo Application Engineers will be at booth M8 — **IRE Show.**

Numerical Listing of Exhibitors

(Continued from page 466A)

4053	GOE Engineering Co.
4054	Inso Electronic Products, Inc.
4055	Saxton Products, Inc.
4056	Chemo Products, Inc.
4101–4102	W. H. Brady Co.
4103	Alpha Wire Corp.
4104	Bodnar Industries, Inc.
4105	United Catalog Publishers, Inc.
4106	Cobehn, Inc.
4107	Electro Devices, Inc.
4108	Zell Products Corp.
4109	Diamonite Products Mfg. Co.
4110	Gries Reproducer Corp.
4111	Oryx Company
4112	Grant Pulley & Hardware Corp.
4113	Derivation & Tabulation Associates, Inc.
4114	Hull Corporation
4115	Great Eastern Metal Products Co., Div. of GEMP Manufacturing Co.
4116	International Eastern Co.
4117	Secon Metals Corp.
4118	Zero Manufacturing Co.
4119	American Sealants Company
4120	Acoustica Associates, Inc.
4121	W. L. Gore & Associates
4122	Design Tool Corp.
4123	Mitchell-Rand Mfg. Corp.
4124	Popper & Sons, Inc.
4125	International Pump & Machine Works, Inc.
4126	F. J. Stokes Corp.
4127	Standard Pressed Steel Co.
4128	McDowell Electronics, Inc.
4129	Technical Wire Products, Inc.
4130	American Aluminum Co.
4131	Robertson Electric Co., Inc.
4132	Jennings Machine Corp.
4133	Ozalid Div., General Aniline & Film Corp.
4134	Temperature Engineering Corp.
4135	Ungar Electric Tools, Inc.
4201–4203	Wilbur B. Driver Co.
4202	Boesch Mfg. Co., Inc.
4204–4206	Premier Metal Products Co.
4205	Artos Engineering Co.
4207–4211	Tinnerman Products, Inc.
4208	H. Braun Tool & Instrument Co., Inc.
4210–4212	Markem Machine Co.
4213	Hitemp Wires, Inc.
4214	W. M. Welch Manufacturing Co.
4215	Cowan Publishing Corp.
4216	Allied Chemical Corp., General Chemical Div.
4217–4219	Belden Manufacturing Co.
4218–4220	George Stevens Mfg. Co., Inc.
4221	Kester Solder Co.
4222	Atlee Corp.
4224–4226	Continental-Diamond Fibre Corp.
4225	Warren Wire Co.
4226A	Signal—Armed Forces Communications & Electronics Association
4227	Krengel Manufacturing Co., Inc.
4228–4230	Associated American Winding Machinery, Inc.
4229	American Molded Products Co.
4231	Hysol Corp.
4232–4234	American Silver Co., Inc.
4233	Technical Devices Co. R & S Electronic Sales Corp.
4235	Kingsley Machine Co.
4236	Lepel High Frequency Labs., Inc.
4238	Aeroprojects, Inc.
4239	York Metal Products, Inc.
4240	Falcon Machine & Tool Co.
4241	Zagar, Incorporated
4242	Molecu-Wire Corporation
4243	Parker-Hannifin Corp., Parker Seal Co.
4301–4303	Electronic Industries
4302–4304	Par-Metal Products Corp.
4305	Electronic Mechanics, Inc.
4306–4310	William Brand-Rex Div., American Enka Corp.
4307	Instruments Publishing Co., Inc.
4309–4311	The New York Air Brake Co., Kinney Vacuum Div.
4312	Perfection Mica Co., Magnetic Shield Div.
4313	Instrument Specialties Co., Inc.
4314–4316	Mc Graw-Hill Publishing Co., Inc.
4315–4317	Falstrom Co.
4318	Kupfrian Mfg. Corp.
4319–4321	E. I. du Pont de Nemours & Co., Inc., "Freon" Div.
4322–4324	Sigmund Cohn Corp.
4323–4325	Leesona Corporation
4326	John Wiley & Sons, Inc.
4327	REF Manufacturing Corp.
4328	Alpha Metals, Inc.
4329A–4329B	E. I. du Pont de Nemours & Co., Inc., Film Dept.
4330	Tensolite Insulated Wire Co., Inc.
4331	Green Instrument Co., Inc.
4401–4403	Driver-Harris Co.
4402	Westline Products Div., Western Lithograph Co.
4404–4406	Hayden Publishing Co.
4405	McGraw-Hill Book Co., Inc.
4407–4409	Industrial Winding Machinery Corp.
4408–4410	Hudson Tool & Die Co., Inc.
4411	Sutton Publishing Co., Inc.
4412–4414	Amco Engineering Co.
4415–4417	Universal Mfg. Co., Inc.
4416	American Super-Temperature Wires, Inc.
4418	Haveg Industries, Inc.
4419–4421	Fairchild Publications, Inc.
4420–4424	Elgin Metalformers Corp.
4423	Birnbach Radio Co., Inc.
4425	The Kanthal Corp.
4426	Coil Winding Equipment Co.
4427	NRC Equipment Corp., National Research Corp.
4428	Federal Tool Engineering Co.
4429	D. Van Nostrand Co., Inc.
4430	Capitol Radio Engineering Institute, Inc.
4431	Tape Cable Electronics Co., Inc.
4501–4503	Dow Corning Corp.
4502	American Lava Corp., Minnesota Mining & Mfg. Co.
4504	Augat Bros., Inc.
4505–4507	Spaulding Fibre Co., Inc.
4506	Buckbee Mears Co.
4508–4510	Halliburton, Inc., Manufacturing Div.
4509	Circo Ultrasonic Corp.
4511	The Consolidated Mining & Smelting Co. of Canada Ltd.
4512	Southco Div., Southchester Corp.
4513	Merck & Co., Inc.
4514	Jonathan Mfg. Co.
4515–4515A	Skydyne, Inc.
4516	John F. Rider Publisher, Inc.
4517–4519	Wall Manufacturing Co.
4518	Penn Engineering & Mfg. Corp.
4520	The Electric Auto-Lite Co.
4521–4523	Synthane Corporation
4522	Beemer Engineering Co.
4524	Eugene Engineering Co., Inc.
4525	Plastoid Corporation
4526	Unitek Corporation, Weldmatic Div.
4527	Pacific Automation Products, Inc.
4528	Metal Fabricators Corp.
4529	H P L Manufacturing Co.
4530	Gardner-Denver Company
4531	Prentice-Hall, Inc.
4532	Narda Ultrasonics Corp.
4533–4535	Carl Hirschmann Co., Inc.

Product Information Service

The following is an alphabetical list of the basic products displayed in the show. After each heading a list of booth numbers is given, where you may see these products displayed. Use the preceding list of numerically arranged exhibitors to find the names of the companies exhibiting the products.

Aircraft & Airport Equipment

1204, 1218, 1409, 1420, 1505, 1507, 1509, 1519, 1704, 1723, 1727, 1727A, 1731, 1819, 1901, 1917, 1925, 1927, 1929, M-12, 2128, 2222, 2241, 2306, 2329, 2343, 2428, 2436, 2510, 2534, 2610, 2615, 2631, 2701, 2738, 2739, 2933, 3013, 3063, 3219, 3237, 3316, 3413, 3707, 3806, 3822, 3919, 3945, 4318

Amateur Equipment

1202, 1305, 1309, 1317, 1401, 1429, 1702, 1712, 1820, 2517, 2919, 3311, 3502, 3505, 3612, 3702, 3915, 4318

Amplifiers

1110, 1202, 1204, 1218, 1219, 1305, 1309, 1402, 1424, 1427A, 1431, 1507, 1509, 1519, 1523, 1620, 1631, 1633, 1702, 1708, 1719, 1731, 1805, 1809, 1811, 1819, 1902, 1927, 2102, 2125, 2202, 2306, 2317, 2413, 2437, 2510, 2517, 2615, 2616, 2714, 2733, 2738, 2919, 2937, 3013, 3017, 3018, 3025, 3027, 3034, 3051, 3052, 3112, 3214, 3219, 3231, 3240, 3302, 3307, 3311, 3402, 3411, 3505, 3512, 3513, 3515, 3601, 3607, 3609, 3612, 3613, 3708, 3712, 3802, 3809, 3826, 3827, 3835, 3836, 3840, 3843, 3844, 3904, 3907, 3915, 3935, 3940, 3946, 3948, 4527

Antennas & Accessories

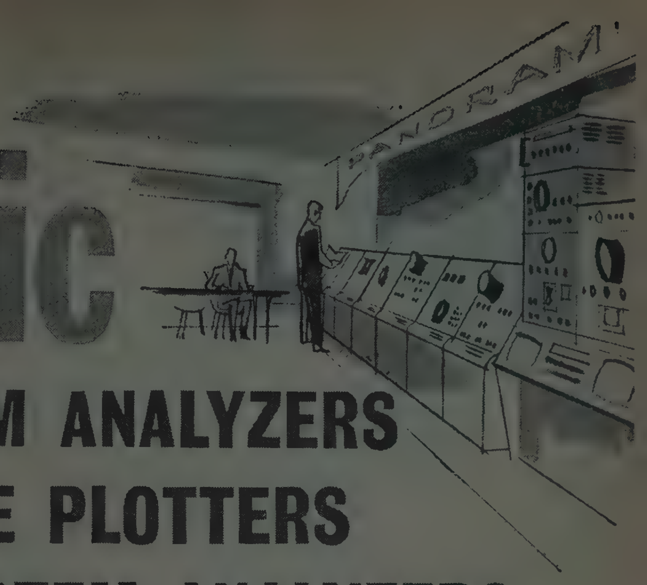
1101, 1106, 1111, 1204, 1207, 1221, 1313, 1317, 1325, 1431, 1502, 1509, 1523, 1609, 1617, 1622, 1630, 1631, 1702, 1712, 1716, 1720, 1723, 1810, 1819, 1929, M-9, M-25, 2113, 2222, 2329, 2339, 2342, 2435, 2510, 2532, 2610, 2615, 2627, 2631, 2706, 2725, 2821, 2835, 2933, 3015, 3043, 3044, 3216, 3225, 3231, 3237, 3316, 3411, 3413, 3414, 3803, 3909, 3920, 3925, 3935, 3936, 4527, 4528

Attenuators

1106, 1110, 1111, 1207, 1313, 1427, 1509, 1716, 1723, 1810, 1905, M-9, 2120, 2241, 2301, 2334, 2339, 2407, 2435, 2603, 2634, 2706, 2710, 2717, 2821, 3019, 3022, 3056, 3216, 3237, 3302, 3307, 3316, 3413, 3501, 3512, 3602, 3701, 3713, 3815, 3827

(Continued on page 470A)

Panoramic

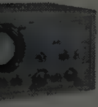


PIONEER IN SPECTRUM ANALYZERS
FREQUENCY RESPONSE PLOTTERS
COMMUNICATIONS SYSTEM ANALYZERS
TELEMETRY TEST INSTRUMENTS

l SPA-3/25

el SPA-4

el LF-2a



el LP-1a

el SB-15a

SPECTRUM ANALYZERS

200cps to 44,000mc

Model SPA-3/25: 200cps-25mc. Versatile "workhorse" instrument for audio through r-f applications. Invaluable for video spectrum analysis.

Model SPA-4: 10mc-44,000mc. Extreme sensitivity, adjustable IF filter width (1-80kc), 70mc dispersion, ONE tuning head and other features for a wide variety of reliable measurements.

NOISE & VIBRATION ANALYZERS

0.5cps to 22.5kc

Model LF-2a: 0.5cps-2500cps. Extreme stability, 0.1-20cps resolution (selectivity), "quick look" spectrum evaluation and inked chart readout for thorough analysis in Subsonic range.

Model LP-1a: 20cps-22.5kc. A time-proved spectrum analyzer for noise, vibration, harmonic, IM and complex waveform studies in many fields.

ULTRASONIC SPECTRUM ANALYZERS

0.1kc-525kc

Model SB-15a: 0.1kc to 525kc. Compact unit features extended range for distortion and vibration analysis, telemetry, communications systems monitoring. Sweep rate, center frequency, sweep width and IF Bandwidth continuously adjustable.

COMMUNICATIONS SYSTEMS ANALYZERS

Single Side Band

Model SSB-3a: 2mc-40mc. Comprehensive analysis with built-in high resolution spectrum analyzer, two-tone Audio generator, stable tuning head, important self-checking features.

NEW Model TTG-2: Distortion-free two-tone audio generator for transmitter testing.

NEW Model TTG-5: RF two-tone generator for receiver distortion testing, linear driver for transmitter power amplifiers.

NEW Model REC-1: Extends range of SSB-3a down to cover 100cps-2mc.

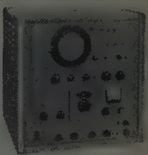
RF • VHF • UHF MONITORS AND INTERFERENCE ANALYZERS

PANADAPTORS . . . uniquely suited to detect off-frequency transmissions, analyze interference caused by splatter, improper carrier location, spurious modulation, parasitics, etc.

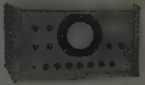
TELEMETRY TEST INSTRUMENTS

Model TMI-1a: 350cps to 85kc. Rapid monitoring of entire subcarrier spectrum, setup of subcarrier preemphasis, measuring and analyzing subcarrier distortion, many other telemetry applications.

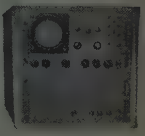
Model TMC-411: NEW simultaneous 11-point Telemetering Frequency Calibrator.



Model SSB-3a



Model SA-8b



Model TMI-1a

Model TMC-411

FIRST in ADVANCED DESIGN . . . APPLICATIONS . . . ACCEPTANCE

Now, see this *growing range* of versatile, economical, easy-to-use instruments, for Research, Development and Production . . . wherever complete dependability is a must.

See them in *Dynamic action* at the show . . . demonstrating solutions to a wide variety of application problems.

If you can't come, write now for the NEW CATALOG DIGEST and technical bulletins. For helpful application information, ask to be put on the regular mailing list for "THE PANORAMIC ANALYZER."

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dependable
CERTIFIED SPECIFICATIONS
for accurate data

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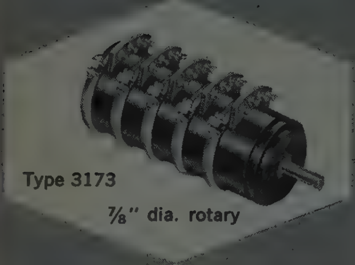
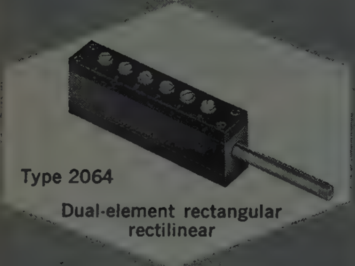
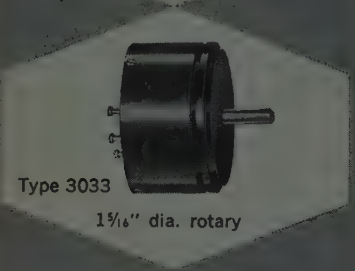
Phone: OWens 9-4600
Cables: Panoramic, Mount Vernon, N.Y. State

BOOTHS 3315-3317, I.R.E.

MARKITE
CONDUCTIVE
PLASTIC
POTENTIOMETERS







When the ultimate in quality and reliability is required . . . when there is no time for standby or interruptions . . . no room for component value variations . . . no tolerance of failure — then it's high time to specify MARKITE precision potentiometers. Here are only a few reasons why they provide performance beyond the expected:

• Linear stability for more than 50 million cycles • Substantially infinite resolution • Independent linearity to 0.05% in 1 5/16" dia. units and 0.01% in 5" dia. units • Operation in ambient temperatures up to 200° C • Shock and acceleration resistance in excess of 100g • Rotational speeds up to 1,000 rpm • Meet Military Specifications.

Write for Design Data and Catalog for Rotary and Rectilinear Potentiometers.

MARKITE
CORPORATION
155 Waverly Place • New York 14, N. Y.

Product Information Service

(Continued from page 468A)

Audio Frequency Test Equipment

1702, 1708, 1731, 1809, 1917, 2306, 2317, 2634, 2717, 2721, 2821, 2840, 3018, 3019, 3031, 3052, 3103, 3105, 3108, 3111, 3116, 3120, 3201, 3210, 3219, 3222, 3225, 3230, 3241, 3302, 3307, 3315, 3402, 3406, 3410, 3414, 3501, 3512, 3513, 3616, 3701, 3705, 3708, 3809, 3811, 3814, 3827, 3833, 3840, 3915, 3929, 3934, 3949, 3952

Automatic Control Equipment

1104, 1219, 1230, 1233, 1409, 1420, 1427A, 1431, 1505, 1507, 1509, 1523, 1620, 1631, 1708, 1728A, 1731, 1806, 1809, 1817, 1819, 1906, 1925, M–2, M–8, 2125, 2128, 2202, 2222, 2237, 2306, 2329, 2343, 2437, 2502, 2610, 2701, 2722, 2739, 2840, 2913, 3008, 3041, 3043, 3044, 3045, 3103, 3115, 3120, 3121, 3219, 3224, 3231, 3232, 3243, 3307, 3308, 3316, 3413, 3612, 3701, 3712, 3807, 3822, 3825, 3831, 3835, 3841, 3844, 3846, 3904, 3916, 4134, 4240, 4318, 4428

Batteries

1116, 1121, 1410, 1901, 2127, 2403, 2416, 2806, 3936

Blowers & Cooling Fans

1234, 1624, 1723, 1919, 1927, M–12, 2229, 2242, 2244, 2601, 2633, 2830, 3926, 4412

Bridges & Decades

1100A, 1219, 1702, 2130A, 2317, 2413, 2603, 2634, 2717, 2721, 2725, 3000, 3009, 3010, 3026, 3114, 3123, 3201, 3220, 3227, 3301, 3307, 3406, 3505, 3607, 3701, 3711, 3825, 3827, 3840, 3929, 4415

Broadcast Receivers

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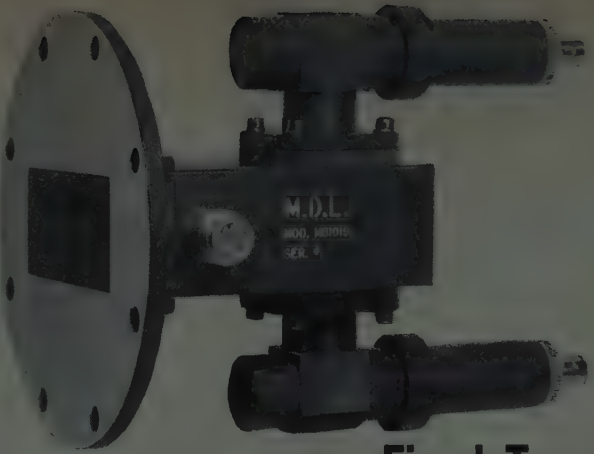

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Freq. (Kmc)	VSWR at waveguide	VSWR at coax	Isolation (db)	Noise figure at 0.5 ma.
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2.7	1.62	1.22	21.0	6.9
2.8	1.60	1.62	24.5	5.9
2.9	1.34	2.00	26.0	5.3
3.0	1.12	1.90	28.0	4.9
3.1	1.07	1.70	27.5	5.3
3.2	1.09	1.60	29.0	5.0
3.3	1.30	1.35	21.5	5.3
3.4	1.21	1.16	26.0	5.4
3.5	1.14	1.20	21.7	5.5
3.6	1.34	1.35	22.5	5.3
3.7	1.63	1.80	23.5	5.3
3.8	1.97	2.10	23.7	5.4
3.9	2.17	1.95	21.2	5.5
3.95	2.05	1.90	21.3	6.9

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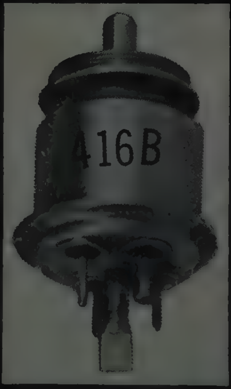

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(Continued on page 476A)

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- EXCELLENT WAVEFORM
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- PHASE LOCKED CIRCUITRY
- REVERSE VOLTAGE PROTECTION

MODEL	POWER RATING	OUTPUT VOLTAGE	OUTPUT FREQUENCY	SPECIAL FEATURES
SIS-40311 series SIS-40511 series	30 VA 1ø 50 VA 1ø	115 VAC adjustable ± 10%	400 cps ± .01 to ± .05%	Precision frequency, excellent waveform, voltage regulated, ± 1% for line, ± 2% load.
SIS-408042 series	80 VA 1ø	115 VAC ± 5 V	400 cps ± 1%	Wide range stabilization, input 18-30 VDC, Voltage regulated ± 1½% no load to full load.
SIS-410042 series SIS-425041 series	100 VA 1ø 250 VA 1ø	115 VAC ± 5%	400 cps ± 1% LC. osc. tuneing fork	Magnetic Amplifier voltage regulated. Rapid on-off switching no transients high efficiency.
SIS-3-425042 series SIS-3-450022 series	250 VA 3ø 500 VA 3ø	115 VAC ± 2%	400 cps ± 2% ± 1%	Regulates to ± 2% with simultaneous variation of zero to full load, and line 25 volts to 29 volts.
SIS-3-47512 series	750 VA 3ø	208/115 V or 115/66.5 volts Adj. ± 5%	400 cps ± .002%	Extreme frequency accuracy. Phase lock circuitry. Magnetic voltage regulator.
SIS-3-40613 series	60 VA 3ø	26 VAC Adj. ± 5%	400 cps ± .01%	Short circuit protected, reverse voltage protection, high temp., + 100°C. Voltage regulated.

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EL SEGUNDO, CALIFORNIA
OREGON 8-2665

Product Information Service

(Continued from page 475A)

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Sockets

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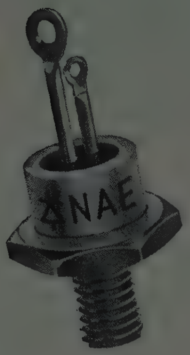

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A three-junction, three-terminal device for use in power control and in switching applications requiring up to 16 amps., D.C. In the reverse direction (anode negative) it will block current up to its rated PIV, while in the forward direction (anode positive) it will block up to its minimum breakover voltage, at which point it will quickly switch to the high conduction state. It may also be turned on when an appropriate voltage is impressed between gate and cathode. In this latter respect it is analogous to a thyratron. In the "on" conduction state, the forward voltage drop is essentially that of a standard silicon diode. Tentative specifications are as follows:

MAXIMUM RATINGS

Peak inverse voltage (PIV) .. 25 to 400 volts
Average forward current (I_f)..up to 16 amps
Peak surge current (one cycle)....150 amps
Peak inverse gate voltage (V_{gr}) .....5 volts
Storage temperature ....—65 to 175°C
Operating temperature .....—65 to 125°C

SPECIFICATIONS AT 25°C

Min. breakover voltage (V_{bo})..25 to 400 volts
Max. leakage current (I_r) and (I_s)......5 ma
Max. forward voltage (V_f avg.).....0.9 volts
Max. gate voltage to fire (V_{gf}).....3.0 volts
Min. gate voltage to fire (V_{gf})......0.3 volts
Max. gate current to fire (I_{gf})........80 ma
Typical gate current to fire (I_{gf})......20 ma
Typical holding current (I_h)..........10 ma
Turn on time..................< 5 μsec
Turn off time.................< 20 μsec

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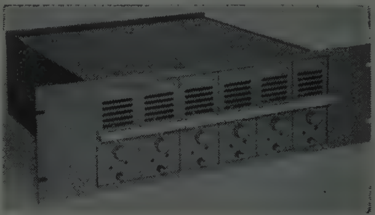
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 60A)

Differential DC Amplifier

A new transistorized differential dc amplifier, featuring a true floating input and stability of 0.05%, is offered by **Neff Instrument Corp.,** 2211 E. Foothill Blvd., Pasadena, Calif.



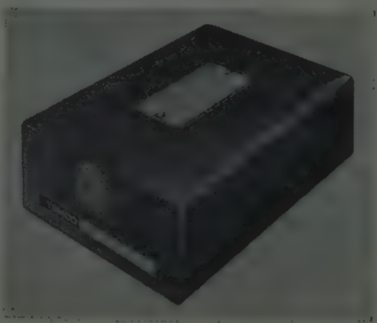
In the new Type 1-102, ground loop or circulating current problems in data processing systems have been eliminated through transformer isolation design. The transistorized amplifier operates with both input and output isolated from each other and from ground. Thus, strain gage and thermocouple data, or data travelling over long signal lines, cannot be destroyed through accidental voltage drops.

The heart of the amplifier is a maintenance-free shielded input module which guarantees high common-mode rejection (100,000,000 to 1). Gain is variable in steps of 10, 20, 30, 50, 100, 200, 300 and 500.

The 1-102 may be obtained in either single unit cabinets or with six amplifiers in a 19″ rack module. The rack module features a self-contained isolated power supply operating the six amplifiers and an integral blower unit.

For complete information write to the firm.

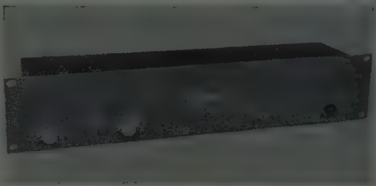
Single Phase Inverter



Temco Electronics, P.O. Box 6191, Dallas 22, Texas, announced a new single phase inverter designed specifically to supply 400 cps power to rate gyro packages. The inverter is suitable for any application requiring small quantities of 26±1.0% volt ac power. Occupying only 20 cubic inches, this unit is capable of delivering 20 watts at 400 cps ±0.1% with an input voltage of 28±4 volts. Distortion is less than 4%. Efficiency exceeds 60% at full load. The rate gyro single phase inverter meets or exceeds all applicable portions of MIL-E-5272.

VHF Preamplifier

Community Engineering Corp., P.O. Box 824, State College, Pa., has designed for use in the 50 to 200 mc range, the Model 1001 VHF Preamplifier with a noise figure of better than 3db at 85 mc and 4.5 db at 200 mc with a nominal gain of 30 db. Unit is fixed tuned to required frequency, band width is 10 megacycles.



The circuit employs a GE subminiature ceramic planar triode, 7077, feeding into a 6AM4, followed by two stages of stagger tuned 5654's.

Amplifier sub-assembly and integral power supply are mounted in light weight, solidly constructed chassis, on a standard size rack panel protected by an easily removable dust cover. Input and output impedance is 50 ohms. Standard type N connectors are used.

Other preamplifiers are available covering frequencies up to 900 mc, also, wide band distributed amplifiers. CECO amplifiers can be modified for special application. Weatherproof enclosure available for installations requiring such protection. For further information, please contact the firm.

Coaxial Attenuator

This variable coaxial attenuator produced by **Merrimac Research and Development, Inc.,** 517 Lyons Ave., Irvington 11, N. J., is the first of a new series of wideband coaxial variable attenuators which have flat attenuation vs. frequency characteristics and zero insertion loss.

The unit shown in the attached photograph of model AE-6 has the following characteristics: Frequency range, 4–7 kmc; Insertion loss, less than 0.5 db; Attenuation variation vs. frequency, less than ±5% in db; Power handling, 4 watts average; VSWR, 1.5 maximum.

These new attenuators provide up to 40 db of attenuation over the above frequency range and special variations with up to 100 db of attenuation. Other types of coaxial attenuators can be provided.

(Continued on page 480A)

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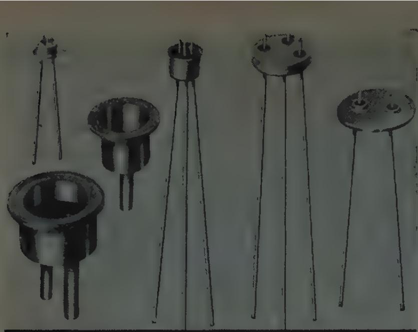

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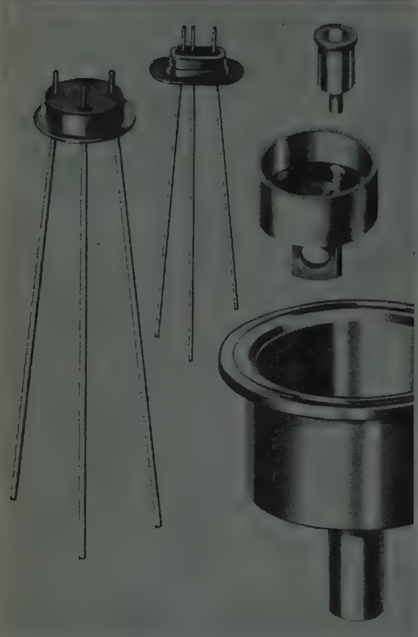

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NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 478A)

Silicon Mesa Transistors

Hoffman Electronics Corp., 3761 S. Hill St., Los Angeles 7, Calif., announced it is now in production on two newly-developed silicon mesa transistors.

Because of design features, resulting in an unusually high small signal current gain, either of the devices will replace up to three transistors of the same classification in many circuit applications, the firm said.

2N697
Hoffman

The new diffused junction, drift field mesa transistors (JEDEC No.'s 2N696 and 2N697), are designed for use as high speed switching units operating at medium power levels and as very high frequency amplifiers.

Hoffman's U-shaped base-emitter configuration is said to allow utilization of virtually all the transistor's emitter area. The minimum high frequency gain at high currents is 6 or more at 20 mc, nearly three times the 2.5 gain of comparable units. This higher gain is due to tighter control of the base width in fabrication.

The new transistors are capable of useful current gains at 40 mc, indicating efficient operation in the ultra high frequency band when operated in a grounded base configuration.

Both transistors are basically control devices for small to large signal switching amplification. The only difference between the two is a higher dc pulse current gain in the 2N697. This measures a minimum of 40 and a maximum of 120 compared to a minimum of 20 and a maximum of 60 in the 2N696.

The company's standards require pre-aging the transistors at 300°C before hermetically sealing them in a controlled inert gas atmosphere to stabilize the electrical parameters.

Total power dissipation of the two transistors is two watts at 25°C case temperature.

The transistors have a maximum collector-base voltage of 60 volts, collector-emitter voltage of 40 volts and an emitter-base voltage of 5 volts.

In saturation, with a base current of 15 milliamperes and a collector current of 150 milliamperes, the emitter-base voltage is less than 1.3 volts and the collector-emitter voltage is less than 1.5 volts.

Price of the 2N696 and the 2N697 is $28.50 each in quantities of from one to 99 units, and $19 each in quantities of 100–999 units.

24 Hour Clocks

In addition to the direct reading digital PlanetGear clocks, **Haydon Instrument Co.,** 165 W. Liberty St., Waterbury 20, Conn., now introduces Model 4003, the first in a series of conventional dial type 24 hour clocks. This is an easy to read, precision built, heavy duty clock made especially for flush panel mounting in an instrument board.

The case and mounting flange are black anodized aluminum. Model 4003 may also be furnished in gray or other colors to match existing equipment. The main figures are $\frac{1}{4}$" high conforming to MIL spec 33558 ASG. and are painted white against a black background. The hour, minute and sweep second hand are also white. The outside diameter of the flange is $6\frac{7}{16}$"; bolt circle is 6" and dial face 5" in diameter. The over-all depth of case is $3\frac{3}{4}$".

Synchronous timing motors available are 50, 60, 400 and 500 cps 110 volts.

The clock has a two year guarantee against defects in material and workmanship.

List price for 50 or 60 cps is $88.00 with discounts for quantity. Delivery about two weeks.

List price for 400 or 500 cps is $120.00 with discounts for quantity. Delivery about four weeks.

SWIRECO

The 12th Annual SWIRECO will feature a National Medical Electronics Conference under the auspices of the national executive committee of the IRE Professional Group on Medical Electronics. Four simultaneous sessions will be held at the Shamrock-Hilton Hotel in Houston on April 20 to 22, 1960.

There will be two general sessions, one medical session, and one student session. Ninety per cent of the available exhibit space has been sold. There will be a full program of activities for the ladies. An attendance of 3,000 is typical for SWIRECO conventions.

(Continued on page 482A)

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AN IMPORTANT ANNOUNCEMENT TO ALL IRE MEMBERS AND SUBSCRIBERS

The IRE Professional Group on Antennas and Propagation has just published the "Proceedings of the URSI International Symposium on Electromagnetic Theory," held at the University of Toronto, Canada, on June 15-20, 1959, as a special supplement to Volume AP-7 (1959) of the IRE TRANSACTIONS on Antennas and Propagation.

Those who registered at the Toronto Symposium will automatically receive one copy as a part of their symposium registration fee. PGAP members and others may obtain a copy by ordering at the rates indicated below. There will be no free distribution because of the special nature and large size of the supplement.

This imposing 400-page volume, comprising invited papers by 54 of the world's leading authorities, promises to be one of the outstanding reference works in its field. The subjects covered include Diffraction and Scattering Theory, Radio Telescopes, Surface Waves, Boundary Value Problems, Propagation of Waves, and Antennas. The complete program may be found on page 18A of the June, 1959 issue of the PROCEEDINGS OF THE IRE.

IRE members and subscribers are urged to order their copies now by returning the form below to the IRE, accompanied by remittance made payable to The Institute of Radio Engineers.

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NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 480A)

Coaxial Attenuator

Microlab, 570 W. Mount Pleasant Ave., Livingston, N. J., has just introduced a new line of coaxial attenuators which are shorter and lighter than those previously available. This new group of attenuators, known as the AC series, operates from 4000 to 12,000 mc and are as short as 2.5 inches.

The AC series of attenuators are constructed as coaxial lines with lossy center conductors. This method is said to result in a unit with VSWR and attenuation characteristics superior at microwave frequencies to those which can be obtained with lumped constant techniques. The variation of attenuation versus frequency is negligible across the entire band.

These attenuators are supplied from stock with N, BNC, TNC, C, or HN connectors at values of 3, 6, 10 and 20 db. Other values can be supplied on request with delivery generally within two weeks. The maximum input power is 2 watts average, 3 kilowatts peak. They are designed to meet the environmental conditions of MIL-E-5272B and other similar specifications. Their over-all length is approximately 2.6 inches for the lower values, increasing to 3.5 inches for the higher values.

The AC series attenuators are available for immediate delivery from stock and are priced at $30 to $45 depending upon the attenuation value and connector type. Further information can be obtained from the firm.

Parts Catalog

Sterling Precision Corp., 17 Matinecock Ave., Port Washington, L.I., N. Y., announces publication of its new catalog #61 consisting of 512 pages with 20,000 items listed from stock. Prices are included.

In its pages are a wide range of gear heads, speed reducers, differentials, precision gears, couplings, shafting, electronic hardware, and so forth.

(Continued on page 484A)

Horizons Unlimited

Development of a high-performance inertial guidance system of unprecedented performance for long-range guided missiles, satellites and space vehicles has been announced by Bell Aircraft Corporation's Avionics Division.

Bell Avionic's engineers describe the highly-classified system as "the most successful and reliable of any new inertial instrumentation concepts so far tested."

The system was developed under the direction of Dr. Helmut W. Schlitt, recognized within the industry as an outstanding authority in the field of inertial guidance.

The new system has undergone extensive flight tests at the Niagara Falls, N. Y., Municipal Airport. Some of its components already are being used in guided missiles.

For more information about Bell Avionics INERTIAL GUIDANCE SYSTEMS AND COMPONENTS, as well as Battlefield Monitoring Systems, All-Weather Automatic Aircraft Landing Systems, Secure Data Link Systems and many others, you are urged to talk to Avionics Division engineers in Booths 3822 and 3824 during the I. R. E. Show.

ELECTRONICS ENGINEERS

Bell Aircraft's *Avionics Division* will conduct interviews in New York City during the I.R.E. Radio Engineering Show March 21 through March 24 for urgently needed competent, qualified engineers in the following categories:

Electronics Engineers to design and develop transistor circuits for digital systems.

Electronics Engineers to design digital and data handling systems in connection with inertial navigation equipment.

Electronics Engineers to analyze digital computers and systems.

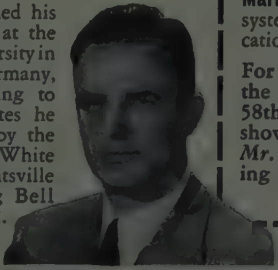
Electronics Engineers to design complex transistor circuits operating over a large temperature range in inertial guidance systems.

Electronics Engineers to design very high frequency receivers and multi-stage transmitters.

Dynamics Engineers to conduct simulation studies of compatability of aircraft with automatic all-weather landing systems.

Marketing Engineers for complex electronics systems involving radar, airborne communications and flight instrumentation.

For a personal, confidential interview at the *Savoy Hilton Hotel,* Fifth Avenue at 58th Street, while you are attending the show, telephone CI 7-2805 and ask for *Mr. George Klock,* director of engineering employment.



Dr. Helmut W. Schlitt, manager of the Avionics Division's Inertial Development Laboratories, who has directed the development of the high-performance inertial guidance system.

Dr. Schlitt earned his doctor's degree at the Technical University in Darmstadt, Germany, and after coming to the United States he was employed by the U. S. Army at White Sands and Huntsville before joining Bell Aircraft in 1952.

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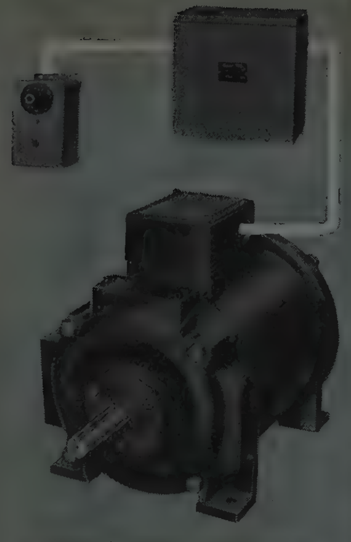

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○ MAINTENANCE Fully encapsulated construction results in long service life. Plug-in construction requires only a screwdriver for servicing.

○ OTHER MODELS Servo-Tek manufactures drives with silicon rectifiers and adjustable autotransformers, as well as other thyratron drives with less exacting specifications. Write for information including details of your proposed use.

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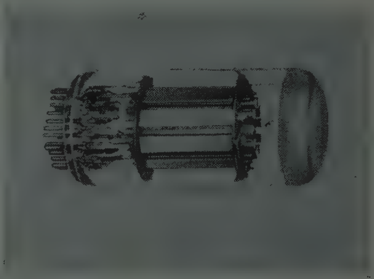
(Continued from page 482A)

Decimal Electronic Switch



The Beam-X, a new decimal electronic switch, is expected to effect a major change in basic electronic design logic from binary to decimal systems according to **Burroughs Corp., Electronic Tube Div.,** Plainfield, N. J. The Beam-X switch uses small rod magnets within a vacuum to control the position of an electron beam to any one of ten output positions. The result is a decimal switch so reduced in size, weight, cost and power as to outperform all existing vacuum, magnetic, and solid state devices in multiposition switching, counting, distributing, multiplexing, and allied operations. In a typical ten-position switching application, the decimal switch eliminates the 90 transistors, diodes, and resistors which must be used with binary logic to achieve the same results.

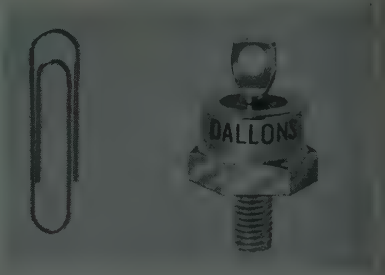
The Beam-X switch type BX-1000 is the first in a new series. Though functionally similar to its predecessor, the Beam Switching Tube, its radical design makes it a completely new device. The BX-1000 is 10 times lighter (1⅓ ounces), 5 times smaller (3 cubic inches) and ⅓ the price (less than $25.00 in small quantities).

The BX-1000 has useful constant outputs, positive switching elements, and memory in each of its ten positions, may remain stationary indefinitely or switch at speeds exceeding 10 megacycles either sequentially or at random, be interconnected as a distributor of any number of positions less or greater than 10, and be preset to any position and reset in less than a microsecond. Operating flexibly and efficiently with respect to B voltages, it can be utilized equally well in high or low voltage systems. In vacuum tube circuits, outputs as high as 200 volts can be obtained while in transistorized systems it can be operated by 12 volt signals directly from the solid state circuitry. Ruggedly constructed to withstand shock and vibration, and insensitive to temperature extremes, the new Beam-X switch is suited for applications in ground support equipment, missiles, aircraft and space technology, and in commercial and industrial products.

Deliveries will start in February with production quantities being available in March.

Silicon Rectifiers

Silicon Rectifiers with ratings of 20–35 amperes, 60–600 PIV which exhibit more stable characteristics at high temperature than before are now available from **Dallons Semiconductors, A Division of Dallons Laboratories, Inc.,** 5066 Santa Monica Blvd., Los Angeles, Calif.



The units contain solders within their construction which have a melting point in excess of 600°C. The $\frac{11}{16}$" stud construction houses a pure silver, heavy spring lead anode assuring ruggedness and high resistance to shock and vibration. Electrical specifications show that these units have less than 5 ma reverse current and the maximum forward drop voltage at a test temperature of 25°C at 20 amperes dc is 0.65 volt.

These units were designed for power supply and magnetic amplifier applications demanding high reliability.

(Continued on page 486A)

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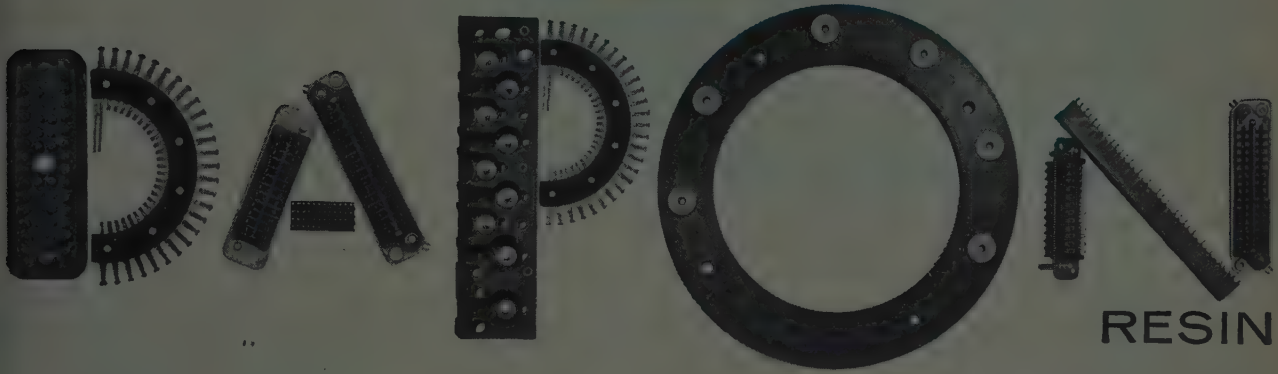

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DAPON® resin (diallyl phthalate prepolymer), a preferred and frequently the only acceptable material in military and space technology applications, is equally well suited to a wide range of industrial uses. Molded DAPON resin parts are widely used today by the leading companies in the electronics industry.

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FMC manufactures the basic DAPON resin only and does not supply finished molding compounds. DAPON resin molding compounds are available from:

ACME RESIN CORPORATION 1401 Circle Avenue Forest Park, Illinois	as	Acme Diallyl Phthalate Molding Compounds
DUREZ PLASTICS DIVISION Hooker Chemical Corp. North Tonawanda, N. Y.	as	Durez Diallyl Phthalate Molding Compounds
MESA PLASTICS COMPANY 11751 Mississippi Avenue Los Angeles, California	as and	Diall® (Diallyl Phthalate) Molding Compounds Diall® (Diallyl Isophthalate) Molding Compounds
ROGERS CORPORATION Rogers, Connecticut	as	Rogers Diallyl Phthalate Molding Compounds

For complete information about DAPON resin's outstanding electrical properties and how it can help solve your problems, write to FMC Chemicals and Plastics Division.

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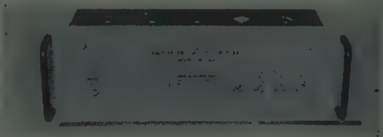
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 484A)

Bandpass Amplifier-Multicoupler

A new distributed bandpass amplifier which provides optimum low noise capabilities and a flat frequency response of from 30 to 300 mc was introduced by **HRB-Singer, Inc.**, State College, Pa., a unit of The Singer Military Products Division.



The 30–300 mc range is obtained from four separate outputs with a minimum input-to-output isolation of 60 db and an average of 30 db isolation between any output.

The HRB-Singer Amplifier-Multicoupler (Model 330-M4) is basically a distributed bandpass amplifier coupled to parallel grounded grid amplifier stages having individual outputs. The amplifier includes an input network which makes possible the optimum low noise capabilities and flat response.

A feature is the parallel connection of the amplifier's six line tubes. With this innovation, failure of several tubes will not seriously lessen the instrument's performance.

The amplifier, constructed with subminiature components and printed circuit techniques, presents a lightweight, rugged package.

The multicoupler case is designed for use in a rack panel installation or for bench experimental testing purposes. The units are shipped ready for use in the rack panel installation and can be removed for bench use by turning the fasteners on the front panels. Identical panel markings are on the sub-panel.

Other specifications of Model 330-M4 are: RF gain 6 db; noise figure 8 db average; input impedance 50 ohms nominal; output impedance 50 ohms nominal; power requirement 117 volts at 1.5 amperes; size $5\frac{1}{4} \times 5\frac{1}{4}$ inches with standard 19-inches relay rack panel; size of power supply $8\frac{3}{4} \times 9\frac{1}{2}$ inches with standard 19-inches relay rack panel.

BWO Power Requirements

The latest issue of "PRD Reports," Vol. 6, No. 4, entitled "Power Supply Requirements of BWO Tubes" discusses the voltage and modulation requirements needed to power backward wave oscillators.

Authored jointly by Stanley J. Blanchard and Martin J. Blickstein, of the staff

(Continued on page 489A)

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HERMOSTATS

RANK FIRST
IN
PRECISION TEMPERATURE CONTROL

In today's military and commercial projects, you ’t afford to overlook any one of these important areas: iability, Size, Availability, Economy.

And because Stevens is in production now on the jest number of different types and styles of bimetal rmostats, all these advantages are yours automatically en you specify Stemco thermostats.

1st in Reliability. Proven designs, latest production nniques, most stringent inspection procedures.

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er to Guide 400EO for U.L. and C.S.A. approved ratings.

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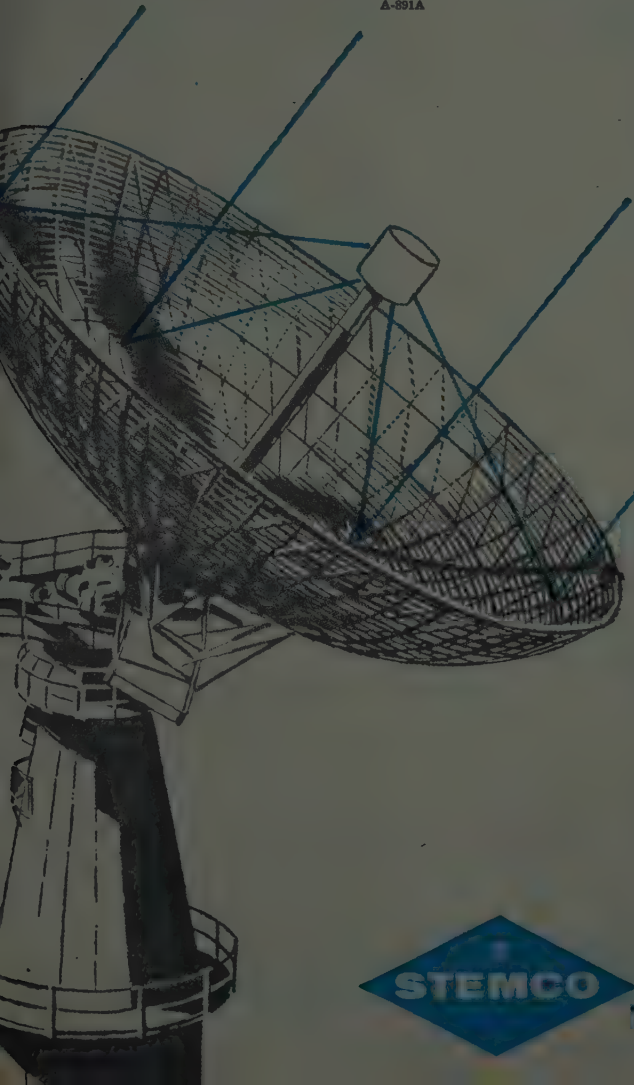


TYPE A* semi-enclosed. Bimetal disc type snap action thermostats; give fast response to temperature changes. Can be made to open on rise or close on rise. Single-throw with double make and break contacts. Operation from -20 to 300°F. Lower or higher temperatures on special order. Average non-inductive rating 13.3 amps, 120 VAC; 4 amps, 230 VAC and 28 VDC. Various mountings and terminals available. Bulletin 3000.

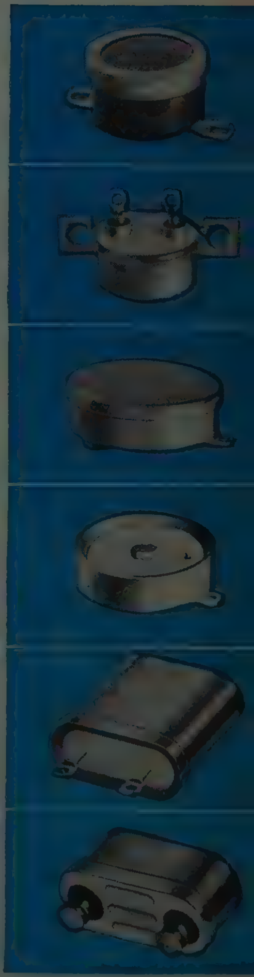
TYPE A hermetically sealed. Electrically similar to semi-enclosed Type A. Various mountings, including brackets, available. Bulletin 3000.

TYPE MX hermetically sealed. Snap acting bimetal disc type units to open on temperature rise. 2 to 6°F differentials as standard. 1 to 4°F differentials available on special order. Depending on duty cycle, normal rating 3 amps, 115 VAC and 28 VDC for 250,000 cycles. Various terminals, mountings and brackets available. Bulletin 6100.

TYPE MX semi-enclosed. Construction and rating similar to MX hermetically sealed type. Bulletin 6100.

TYPE M hermetically sealed. Bimetal disc type, snap acting thermostats. Also available in semi-enclosed. Operation from -20 to 300°F. Lower and higher temperatures available on special order. Depending on application, rated non-inductive 10 amps, 120 VAC; 3 amps, 28 VDC. Various terminals, wire leads and brackets available. Bulletin 6000.

TYPE C hermetically sealed. Also semi-enclosed styles. Small, positive acting with electrically independent bimetal strip for operation from -10 to 300°F. Rated at approximately 3 amps, depending on application. Hermetically sealed type can be furnished as double thermostat "alarm" type. Various terminals and mountings. Bulletin 5000.



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NEWS New Products

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(Continued from page 486A)

of **Polytechnic Research & Development Co., Inc.**, 202 Tillary St., Brooklyn 1, N. Y., the report describes the theory and operation of both M and O type tubes. The relationship between power output, frequency shift, and delay line current stability is graphically presented as a function of various electrode voltages.

The PRD 813 Universal BWO/TWT Power Supply is discussed in detail and a partial listing of the Backward Wave Oscillator tubes that the supply can operate is shown.

Copies of the Report are offered by the firm on request.

VHF Admittance Bridge

A miniature thermistor element working in a servo feedback system is used as a conductance standard in a VHF Bridge Model 978 manufactured by **Marconi Instruments**, 111 Cedar Lane, Englewood, N. J. This approach is said to guarantee measurement accuracy of 2% to 300 mc. Capacitance and conductance range is ±40 $\mu\mu$f and 0–50 millimhos. (Illustrated are: Admittance Bridge Model 978 and Bridge Source and Detector.)

Two terminal measurements can be made on RF components, semi-conductors, transmission lines, and so forth. The voltage applied to the component under test is small, seldom more than 50 mv.

Separate bridge sources and detectors are available for operating the bridge, although any signal generator and receiver covering the frequency range can be used.

For detailed information write to the firm.

Gas Tube Noise Sources

Supplementing the recently announced development and production of compact gas tube noise sources for ground and airborne microwave system applications, **Tucor, Inc.**, 18 Marshall St., South Norfolk, Conn., introduced additional coaxial models for the 200–250 mc frequency range. Available at the T44V series, these new noise sources feature high excess noise outputs. They are suitable for test and calibration of all types of microwave and communications components and systems.

(Continued on page 490A)

FREQUENCY
FLOW
RPM
with
in line
NIXIE
readout

NEW
low cost
multi-purpose
electronic
counter

Model 720 events-per-unit-time counter is specially designed for industrial and laboratory uses where unusual flexibility is required. The unique modular construction permits the measurement of virtually any physical variable, such as rate of flow, RPM, frequency or time interval. NIXIE in-line readout is easy to read and reduces operator fatigue and the chance for error. Simplified construction permits operation by relatively unskilled personnel. Low Cost starts at $475 for the 3-decade model. Send for complete technical literature.

DECADES:	3, 4, 5 or 6
FREQUENCY RANGE:	0 to 120,000 pulses/sec.
SENSITIVITY:	50 Millivolts RMS
ACCURACY:	± one count time base error
DISPLAY TIME:	0.2 to 6 sec. or infinite
SIZE:	19″ x 5¼″ x 12″
WEIGHT:	25 lbs.

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- **INDUCTANCE RANGE:** 0.10 to 4700 μH
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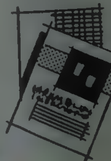

ESSEX ELECTRONICS
DIVISION OF
NYTRONICS, INC.
550 Springfield Ave., Berkeley Heights, N. J.
CRestview 3-9000

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 489A)

The T44VIC is one of several models now available. This noise source is housed in a rigid coaxial line and provides an excess noise ratio of 18.5±0.3 db. The T44VIC is suitable for CW or pulse operation under typical adverse military environments, and will meet all applicable military specifications for shock, vibration, temperature and humidity. The T44VIC will fire and operate at conventional power supply voltages and will operate reliably for a lifetime in excess of 2000 hours.

Two additional models, the T44V2C and the T44V3C, are also available. The T44V2C features a replaceable gas tube element as well as a higher noise output of 21.0 db. The T44V3C also features the replaceable gas tube element, at a noise output of 18.5 db.

For special applications as to frequency or noise output, Tucor can provide a noise source tailored to your requirements. Coaxial versions of the T44V series are available at frequencies up to 1000 mc.

Sampling Switch

Instrument Development Laboratories, Inc., a subsidiary of Royal McBee Corp., 67 Mechanic St., Attleboro, Mass., announces it has, within 4 months, designed and produced a new 2-pole, 60 position, motor-driven, low-level sampling switch which has run continuously at 60 rps for more than 200 hours without contact bounce or signal contamination. This switch has performed satisfactorily while undergoing missile vibration testing of 20 to 3000 cps at 35 "G's" for 35 minutes per asis. Designed for application to an Area Defense Missile Guidance Radar System, this switch samples Doppler velocity data for range-rating purposes. With the cooperation of the systems contractor, this

(Continued on page 492A)

FOTO-VIDEO

Modular
Power Supplies
For YOUR System

OFF the SHELF

WHY WORRY and spend valuable Engineering Design Time, when one of our regular power supplies (or a slight modification), will do your job?

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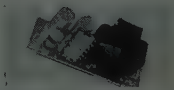
- Large Power Handling
- Compact; High Efficiency
- Line and Load Regulation
- Zero Warmup; Short Recovery Time
- Short Circuit Protected
- Continuous Rating; Conservative
- Long Period Stability
- Extremely Low Ripple
- Rack Height Economy
- Excellent Mechanically
- Swing Out Chassis
- Continuous Duty; 50-400 Cycle
- 6.3 and 5 vdc Outputs
- Most Models Line and Load Regulation



SPECIFICATIONS

Model	Input	Amps	Volts	Reg. %	Ripple mv.	Max. Source Imped. Ohms	Price
P-37A	22-30 VDC	2.0	21	0.5	3	0.5	$ 95
P-37B	22-30 VDC	2.0	16-21	2.0	10	2.0	59
P-41A	22-30 VDC	2.0	28	0.5	3	0.5	125
P-58A	115V-125V 50-400 Cy	0.250 0.005 and	150 150	0.5	3	0.5	343
P-60A	115V-125V 50-400 Cy	3	28	1.0	10	0.5	250
P-91A	115V-125V 50-400 Cy	1	24-32	1.0	1	0.5	295
P-291A	115V-125V 50-400 Cy	0.250	50-60	0.5	1	0.5	350
P-158A		Two P-58's + one P-41		0.5	3	0.5	595

Note 1: All the above except P-158 are compact modules.
Note 2: P-158 has 3 modules in 19" rack, 5¼" high.
Note 3: Many other models. Write for catalogue.

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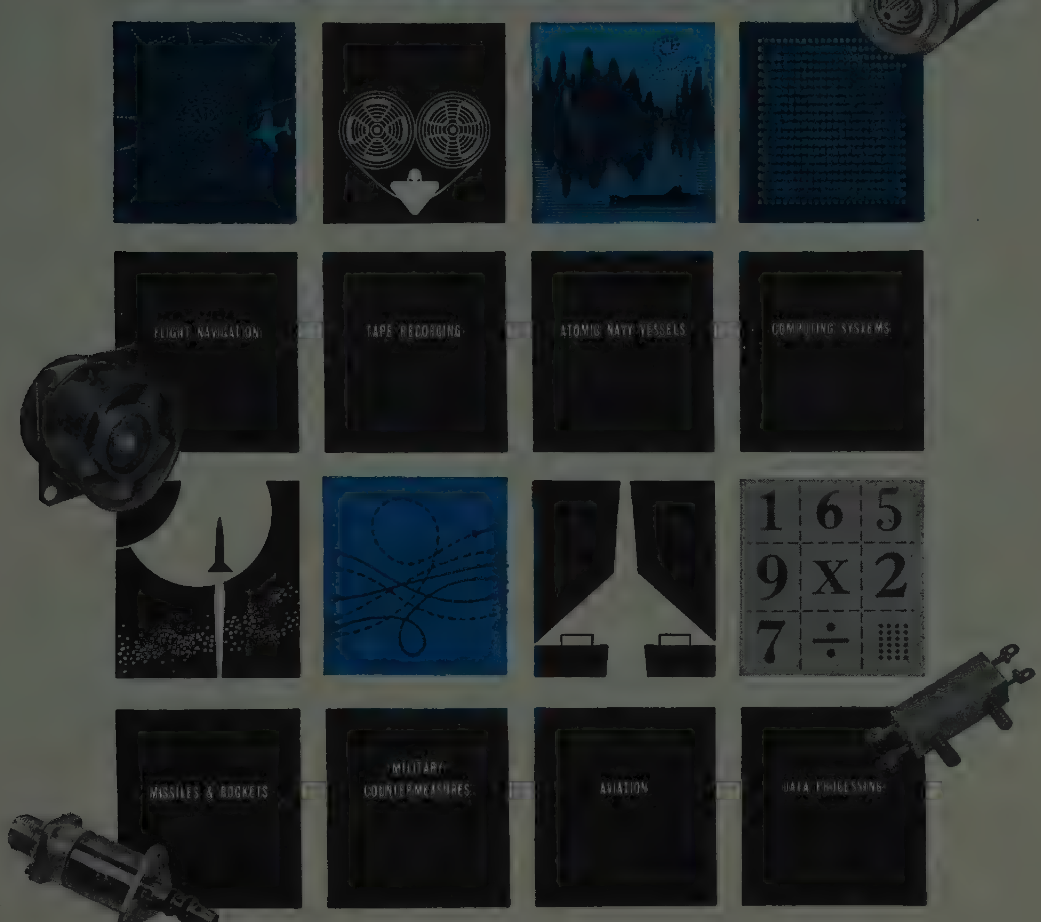
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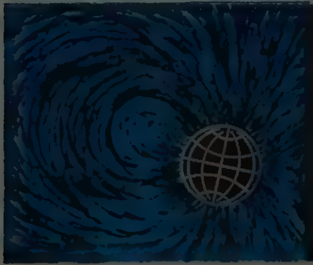
HOW THESE CAPABILITIES CAN HELP YOU: New expansion and diversification programs now permit IMC to offer a broader scope of precision products. Our goal: Ever-increasing product reliability; accelerated progress in sub-miniaturization ■ IMC precisioneered components will not only help you design smaller and better, but will permit your systems to reach new realms of operational reliability ■ **MOTOR TYPES: SERVO, TORQUE, HYSTERESIS, DC, STEPPING • VANEAXIAL FANS • CENTRIFUGAL BLOWERS • PROPELLER FANS • TACH GENERATORS • SOLENOIDS • SYNCHROS • DELAY LINES**



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NEWS New Products

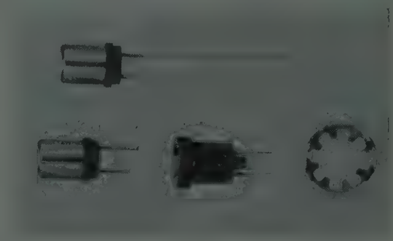
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 490A)

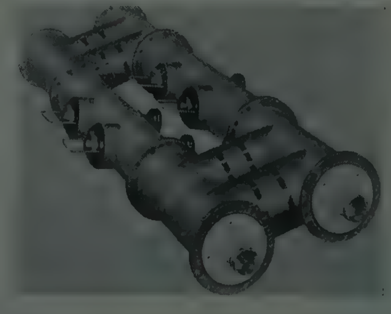
switch has been custom designed to be an integral part of the radar packaging. It occupies 43.7 cubic inches, weighs less than 2.5 pounds and consumes 7 watts of power at 100 volts, 400 cps single phase.

Precision Sub-Miniature Fuse

A new development in fuse construction which allows close resistance tolerances, high reliability in fast blowing characteristics, and complete miniaturization for applications where space is at a premium, has been announced by **Littelfuse, Inc.,** Des Plaines, Ill. The new subminiature fuse, known as Microfuse, measures 0.205″ diameter × 0.070″ long. The development behind Microfuse is based on the bead type construction pioneered by Littelfuse in their instrument fuses. This construction along with a new type of filament wire permit uniform resistance and blowing characteristics across the range from 1/500 ampere thru 5 amperes at 125 volts. Blowing specifications are: Life—100% of rating; 0–10 seconds—150% of rating. The devices are available either in pigtail variety, which is especially adaptable for soldered connections, or in the plug-in variety, which is designed to plug into a special sub-miniature fuse holder for chassis or printed circuit board mounting.



Balanced Coaxial Line Duplexer



Bomac Laboratories, Inc., Salem Road, Beverly, Mass., announces a balanced coaxial hybrid and two cavities for "plug-in" cell-type TR tubes. This unit is in 6⅛″ line and is rated to handle 10 kw of average power. Other units of this type are available in 1⅝″, 3⅛″ and 6⅛″ coaxial line.

Airborne Mounting Systems

Robinson Technical Products, Inc., designers and manufacturers of all-metal vibration and shock control mounting systems, has developed two types of mountings which successfully isolate airborne communications equipment from high intensity environments.

Suitable for either military or commercial aircraft, these two designs together compose 55 variations, and are available in many ATR sizes, a wide variety of load ranges, and numerous DPA and DPD connector arrangements.

Model 2310 is a center-of-gravity system designed to accommodate the smaller ATR configurations. The single stage mounting base requires only four pre-spaced mounting holes, making misalignment impossible. Natural frequency is in the 6–10 cps range with a transmissibility at resonance of less than 5.

Model 2311 is a base type system for larger ATR equipments. Possibility for misalignment during installation is likewise eliminated through the use of four pre-spaced mounting holes.

Each of these mounting systems incorporates MET-L-FLEX stainless steel resilient elements, and each has been designed to meet specifications ARINC 404 and MIL-C-172B.

For further information, write to the firm.

Oscillator/Phase Shifter

The Industrial Test Equipment Co., 55 E. 11th St., New York, N. Y., has developed a new instrument for the precision measurement of phase angles in the vicinity of 90°. The instrument consists of an 8 watt power oscillator and a precision variable phase shifter having a range of 90°±10°. The resolution and incremental accuracy of the phase shifter is 0.05°. The absolute accuracy is better than 0.25°

(Continued on page 494A)

Above: Nose cone test shape traveling at 5,500 feet per second photographed with Avco Schlieren System at 0.05 μsec exposure. Inset: Avco Kerr Cell. Permits exposure from 0.005 to 0.1 μsec; available as an independent module.

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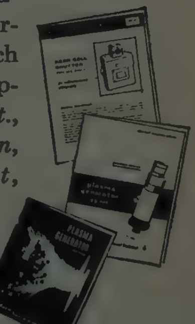
Write for bulletins describing Avco's products and systems in the fields of Hypervelocity Instrumentation, Major Research Facilities and Environmental Test Equipment. *Write to: Products and Services Dept., Research and Advanced Development Division, Avco Corporation, 201 Lowell Street, Wilmington, Mass.*



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(Continued from page 492A)

throughout its range, and better than 0.1° at the 90° point. The power oscillator can be used to excite the amplifier or component under test. The standard frequency is 400 cps, however, other frequencies can be supplied.

The phase shifter output may be used for measurement of phase angle, or quadrature voltage components, or may be used as a signal source for the precise excitation of 2-phase devices.

Direct Printing CR Tube

A new Litton cathode ray tube type has been developed for direct electronic printing at high speed on non-sensitized dielectric material, according to an announcement by the display devices department of the **Electron Tube Div., Litton Industries,** 960 Industrial Rd., San Carlos, Calif. The tube is tradenamed "Printapix".

First showing of two models of the new tube, in a $2\frac{3}{4}$" printing head width, will be made during the IRE Show. Both models are available for immediate delivery. Tubes with up to 12" printing head width can be produced to specific order.

This versatile new electronic component is already being incorporated in facsimile, oscillography, address labeling and television type image reproduction equipment. Other applications soon will include high speed computer readout, controlled information storage and erase for military tactical display maps and stock control uses, projection transparency generation, multiple copy reproduction, and simultaneous recording at any number of dispersed stations.

Tubes employing the above techniques, but utilizing much closer spacing of the writing elements, in order to accurately print minute detail, can be furnished for specific application. Element densities up to one million per square inch are feasible.

Operating circuitry and components of the new Litton Printapix tubes are similar to those normally used for display, readout or oscillographic applications. Ordinary television components and techniques are quite satisfactory in many instances. For operating convenience, the

(Continued on page 498A)

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This is definitely a "Tall Story," the proof of which is at the Martin Company, Denver Division for Missile Testing. Shielding, Inc. was awarded the contract to engineer six gigantic RF enclosures, **100 feet in height,** for the "Titan" missile, because Shielding has come to be recognized as the leader in the shielded enclosure field.

Although the shadow cast by these giants is long, it in no way over-shadows the more modest in size RF shielded enclosures which incorporate the latest in mechanical and electrical design features.

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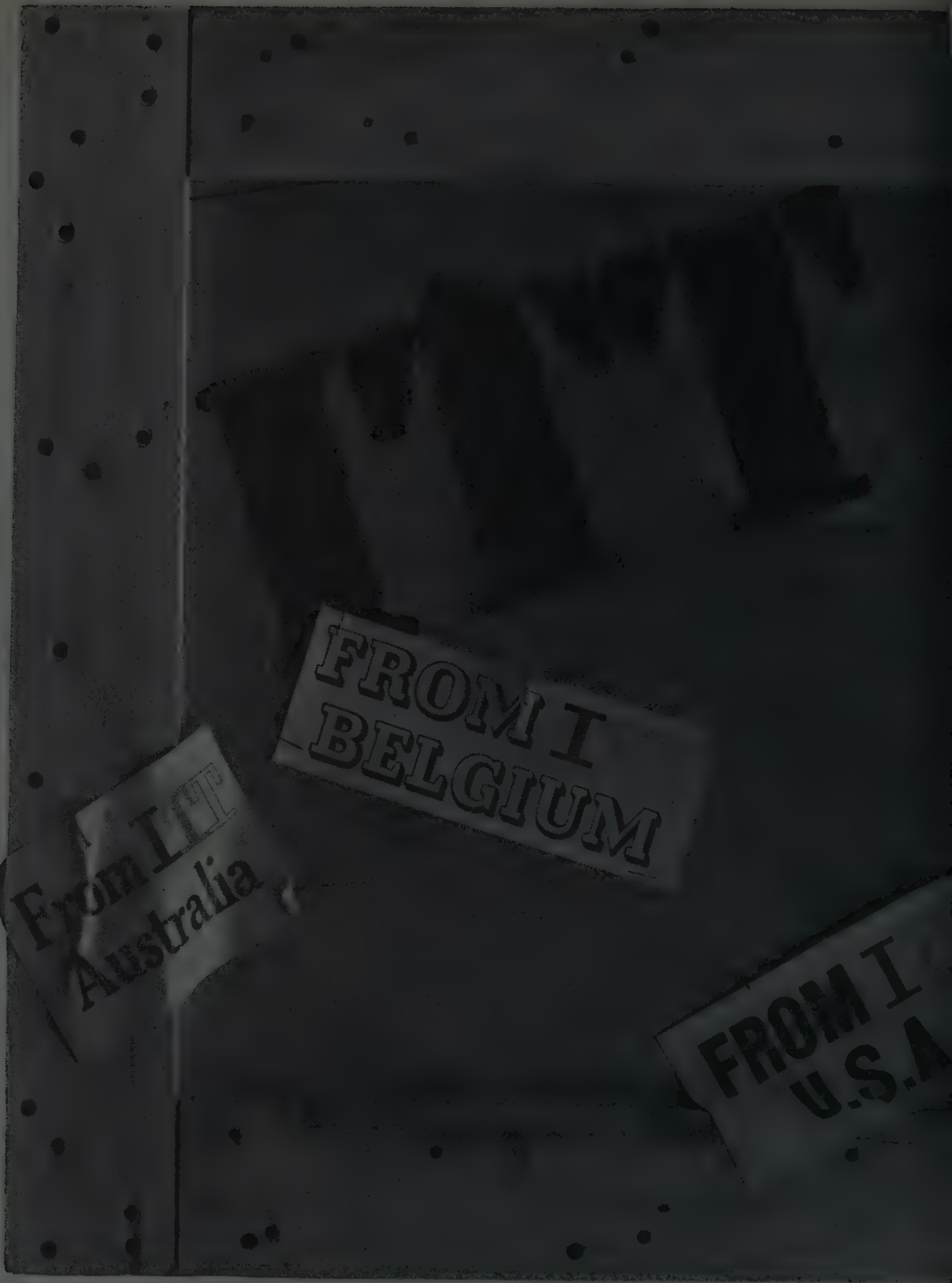

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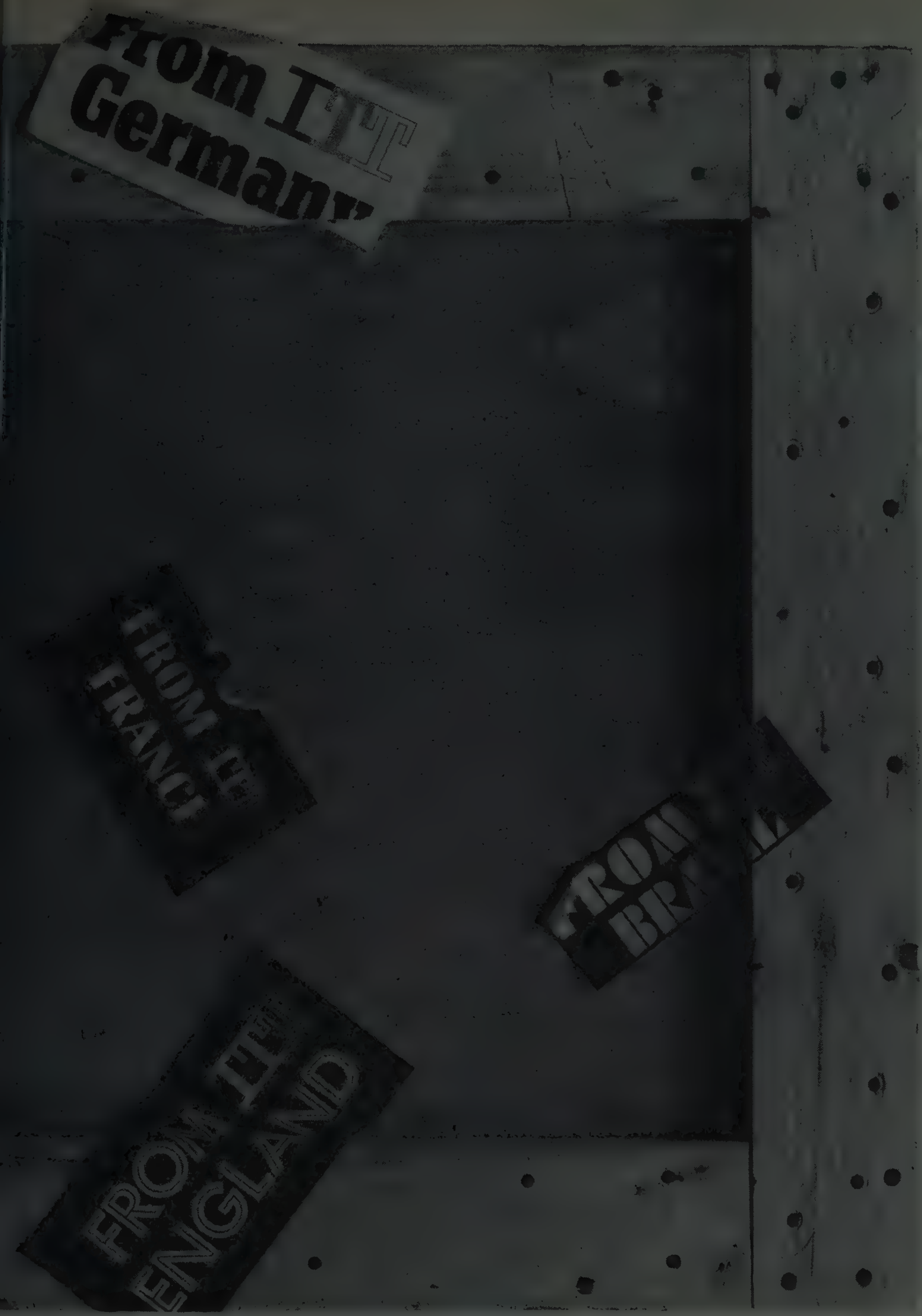

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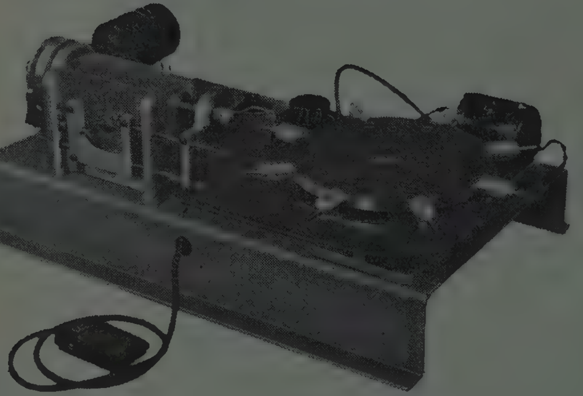
the modern way to cut costs... save time

Latest in Coil Winding Equipment Company's wide variety of high-speed coil winders for all possible needs is the Model CK, designed to take maximum advantage of the time and money saving principles of automation. The Model CK meets most applications, minimizes maintenance, and cuts down considerably on the need for special-purpose, custom-built equipment.

MODEL CK



The Model CK features Coil Winding Equipment Company's recently-developed turret transfer. In combination with a suitable winding head, the ingenious turret transfer permits adding — *only as needed* — hopper feed for the coil forms; stripping, cementing, taping and cutting attachments. The Model CK will produce complete bobbin or single-layer coils without operator attention when equipped with a hopper or magazine for the coil forms and appropriate standard attachments, and it will provide stations for finishing as required.

We'll be pleased to send you complete information. Write or phone

Coil Winding Equipment Co.
OYSTER BAY N.Y. – OYster Bay 6-1285

VISIT BOOTH #4426

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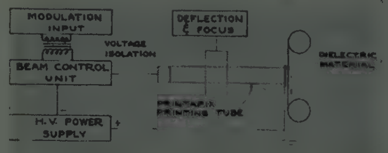
(Continued from page 494A)



OPERATIONAL BLOCK DIAGRAM

tube is frequently run with the printing head at ground potential.

Used with the new Printapix direct writing tube, ordinary paper provides a low cost base material for image rendition. Paper with a glossy surface, commonly used in many printing applications, will provide excellent results. Printing quality can be improved by rendering the opposite side of the paper slightly conductive. Various transparent media, such as glass and thin transparent plastic or commercial sheet polyesters, may be used with Printapix. Dielectric material transport requirements depend on the proposed application.

Image development with the new Litton Printapix direct writing tube is a simple, inexpensive, instantaneous and dry operation. One system employs a developing powder with two components, a toner and a carrier. Agitation of the combination produces a tribo-electric charging. The toner is a finely pigmented plastic material which becomes positively charged, and is thus attracted to the negative charge image on the dielectric material. A typical carrier material is powdered iron.

The developing powder is released as a cloud or fog in close proximity to the charged dielectric surface. Pigmented plastic is attracted to and retained on the charged areas by the coulomb force. The resultant image can subsequently be erased for reuse of the base material and powder, or be permanently fixed by a rapid heat cycle, pressure or other means. Since the resultant image color is determined by the pigment, multicolor reproductions may be obtained by proper development.

AC Ratio Boxes

A new line of precision AC voltage dividers are featured among the instruments and instrument systems demonstrated by **North Atlantic Industries,** Plainview, L.I., N.Y. at the 1960 IRE Show.

(Continued on page 500A)

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NEWS New Products

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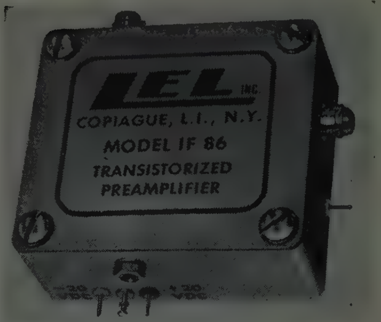
(Continued from page 498A)

Designated series RB-500, the group includes, portable, bench and rack mount models, in general purpose, deviation, sine-cosine, binary and automatic stepping types. In all models precise voltage division is accomplished by means of an adjustable ratio transformer. Unlike resistive dividers, design provides the advantages of high input and low output impedance, preventing loading of the input circuit and minimizing the effect of capacitance between the bridge arms and ground.

All models feature in-line window readout, and provide a range of ratios from +1.111111 to −0.111111. Measurements about zero and unity, consequently, are accomplished without the need for disrupting test set-ups, as required with dividers that do not provide below-zero settings.

Depending upon the particular model, accuracy specifications are 1 ppm to 10 ppm. The unique design features of the instrument provide rated accuracy both above and below zero ratios. Bench and panel mounting types are designed to occupy minumum space and include input and output connections on front and rear, permitting ready integration into consoles, carts and similar larger instrument systems.

IF Preamplifier



A new transistorized IF preamplifier further supplements the standard line of transistorized equipment designed for use in missile, space, and telemetry applications by **LEL, Inc.,** 380 Oak St., Copiague, N. Y. The Model 86 has a bandwidth of 20 megacycles centered at 60 mc and designed to be used with microwave receiver mixers having an IF source impedance of 300 ohms and 18 $\mu\mu f$. Noise figure is better than 4.25 db. The Model 86 is also available at other center frequencies and for other source impedances.

Insulation Coating

A high temperature, heavy-duty service, insulation and protective coating, HumiSeal Type 1H34, has been announced by **Columbia Technical Corp.,** 61-02 31st Ave., Woodside 77, N. Y. This coating is practical in many military applications and particularly in those where radioactive environment is involved. A one-component system on silicone resin basis, HumiSeal 1H34 is characterized by 6-month long pot life and excellent electrical properties at temperatures above 400° F. HumiSeal 1H34 may be applied by spray, dip or brush. Further data available from the firm.

DC Drive Choppers

Stevens-Arnold, Inc., 7 Elkins St., South Boston 27, Mass., will release at the IRE Show, March 21–24, Booth 2934, a complete line of DC Drive Choppers, both SPDT and DPDT, featuring low noise and a 94-cps chopping rate. Catalog 554 gives all information and prices.

DC-AC CHOPPER
DPDT
STEVENS-ARNOLD, INC.
SO. BOSTON, MASS.

In portable equipment the availability of these choppers makes it possible to build high performance circuits designed around a chopper with a noise level specification of 1 microvolt into 100,000 ohms.

In the non-portable field, the substitution of a dc drive for the conventional ac drive means that the ac drive wiring is removed from the circuitry. The power supplies used with transistorized circuits are well suited to supply the 12 or 24 volts dc required to drive the chopper.

Subminiature Transistor Pulse Transformers

The development of the Type BME series of hermetically-sealed subminiature low power pulse transformers for use with transistorized blocking oscillator and interstage coupling circuits, has been announced by **Technitrol Engineering Co.,** 1952 E. Allegheny Ave., Philadelphia 34, Pa.

The Type BME units are available in a range of pulse widths from 0.05 to 5.0 μsec at repetition rates up to 10 mc. The trans-

(Continued on page 502A)

PREMIER MICROWAVE COMPONENTS
FLAT LINE
MINI-MIX
BROADBAND COAX MIXER
UTILIZING REPLACEABLE PRINTED CIRCUIT DIODE
Specifications
- SIGNAL VSWR—2:1 MAX.
- L.O. VSWR—1.5:1 MAX.
- 250 to 4000—9db Noise Figure
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Assemblies with 16 channels. 24 inch paper permits up to 24 channels on one inch centers.

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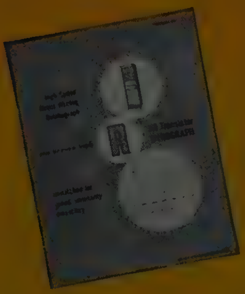

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Features horizontal paper travel. Available as Type R or RC.

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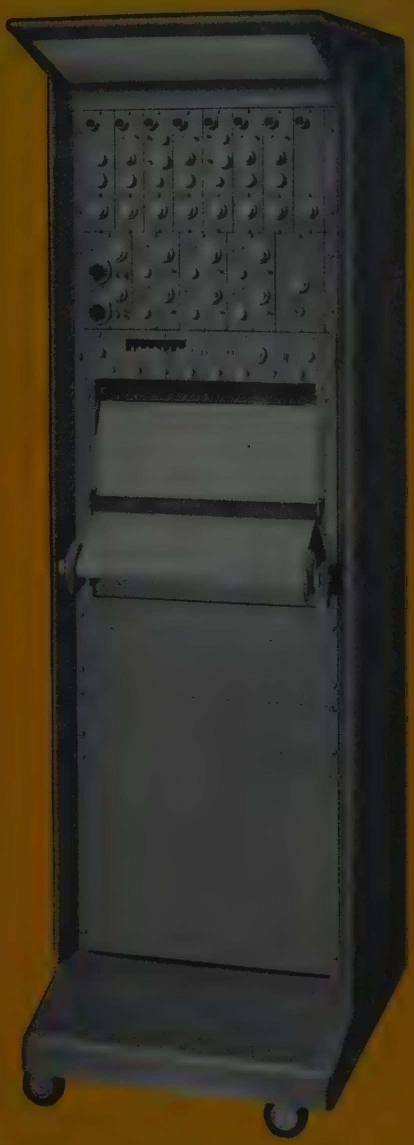
Medium gain assembly for computer write-out, telemetering, applications with input signal above 10 millivolts.



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The Offner Type R Dynograph Assembly is unmatched for sensitivity, accuracy, versatility—we invite you to compare it with any other high speed direct writing oscillograph.

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NEWS New Products

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(Continued from page 500A)

formers are wound on high permeability ferrite cup cores and are hermetically sealed in cylindrical brass cases approximately $\frac{1}{2}''$ long with a diameter of 0.4″. The units can be obtained with two or three windings and a choice of nine different turns ratios. Connections are provided through pig-tail type leads, $1\frac{7}{8}''$ minimum length.

The transformers are available in three grades designed to meet different environmental specifications: Commercial Grade, operating at temperatures from −25° to +105° C; MIL Grade, operating from −55 to +105° meeting Grade 5, Class R requirements of MIL-T-27A and MIL-T-21038; and X-Grade, which meets all MIL Grade requirements and has an increased temperature specification to +150° C.

Microwave Attenuators

This new series of low temperature coefficient microwave attenuators is available in 3, 6, 10 and 20 db from **Microwave Control Corp.**, 250 W. 57th St., New York 19, N. Y. The attenuators are available in type N fittings and cover the range of 1 to 10 kmc with low VSWR. The attenuators employ precision vacuum evaporated metal film resistors with a T_c of 280 ppm, resulting in fixed attenuators exceptionally stable from −55° C to +125° C.

High Speed Sampling Relay Catalog

A catalog just released by **James Electronics Inc.**, (formerly James Vibrapowr Co.), 4050 North Rockwell St., Chicago 18, Ill., illustrates and gives full technical details of the firm's new line of "Micro-Scan" relays designed for DC, asynchronous and synchronous switching of extremely low microvolt level to moderate level signal circuits such as found in digital, analogue and measurement applications.

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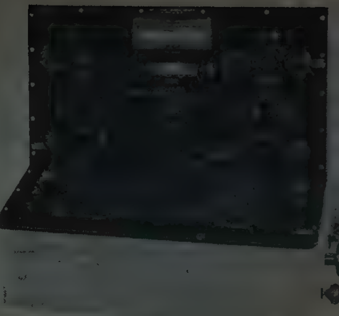
Calibration Console. Accuracy ± .05% of actual reading DC to 25kc. Ranges .5v. to 1111v. and 1 ma. (2 ma. on AC) to 11.11 amps in decades of .1v. and 1 ma. Resolution ± .01%. Direct read-out in % error as well as in actual values. Console consists of a Hermach type AC-DC thermal transfer standard and a separate DC Calibrator. Complete with ± .005% stable reference source, high sensitivity galvanometer and self contained controls. Designed for one-man operation! Model LT-PS is a wide range, low distortion (.1%), highly stable AC power supply designed to operate within the full capabilities of the console.



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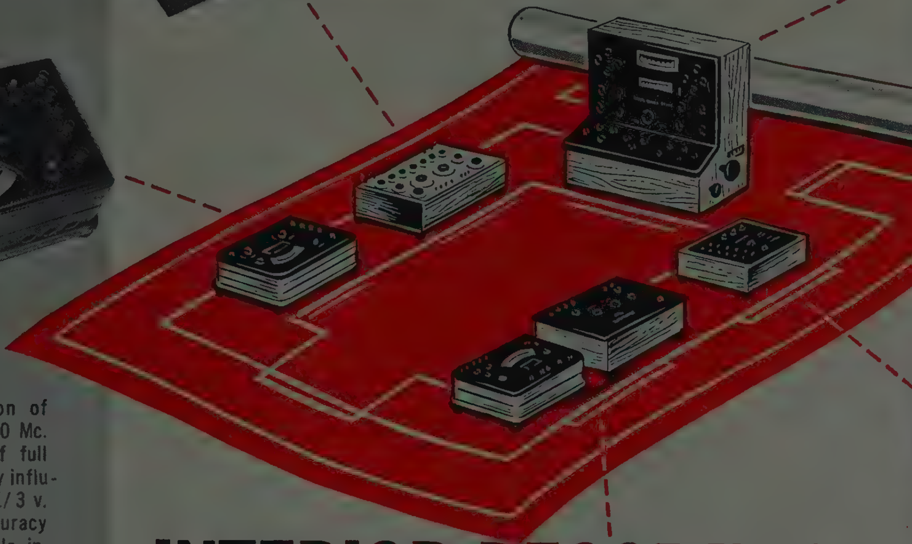

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Model STV

± .01% accurate, ± .005% stable DC reference source! Ranges 1.0000v. and 1.0185v. For use with "null balance" devices such as potentiometers and other infinite impedance comparators. Unaffected by vibration, extremes of temperature, or changes in operating position. Can be short circuited indefinitely without affecting accuracy or life expectancy. Input 90-140v. at 15°c-35°c.

ide Range Calibrator, Laboratory Standard and General urpose Power Supply. Model Thach: AC/DC "Self Check-ng" Volt-Amp-Milliammeter. Accuracy ± .2% to 4kc. anges 10/20/50/100/200/500 ma.; 1/2/5 amps; 1/2/ /10/20/50/100/200/500/1000 v. Checks its own accu-acy against an internal standard cell. Model Thach-PS: egulated power supply with interlocking controls. Auto-atically shuts off power to the Model Thach when switch-g ranges, reducing danger of accidental overloading of tandard and/or instrument under test. Output is DC and 0 cps. (50-2500 cps can be plugged in).

Model THACH AND THACH-PS

REDECORATING!? . . . make sure you see SRIC's approach before you make your final plans. While most instrument manufacturers have gone "fascinatingly electronic," SRIC has been moving into the complete field of accurate and dependable measurements through the application of fundamental electrical indicating instruments and primary standards. Words like "Automation" and "Versatility" have not been ignored . . . in most cases they've just been combined with "Reliability." Whatever your interest . . . Primary or Secondary Standards . . . Portable, Panel or Special Instruments . . . investigate Sensitive Research . . . the electronic world's most respected manufacturer of reliable measuring equipment!

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F-28/APN-19 FILTER CAVITY

Jan. spec: Tuneable 2700-2900mc, 1.5db max. loss at ctr freq over band. Details: Insertion loss variable. Single tuned filter for freq channelling in radar beacon. Silver plated coax resonator. Invar center tuning conductor ¾ wavelength. Tuneable 9-11.2cm. Loaded Q 450-650 for insertion loss at band ctr 1db. 700-1000 for loss 2 to 3db. Band center stable to 1mc/sec for 100 deg. C amb. temp change. A double tuned cct with a flat response over wider band pass and less critical tuning had by cplg. two filters in series. New. $37.50 each.

RADAR REACON RCVR R-139/APN-19. Comprises microwave RF crystal detector, video amplifier stages, duty cycle limiter, locking osc, control circuits. Operates on 2 channels in 2600 to 3400mc region with band width of 300mc when F-28 (above) is not used. In pressurized housing 10" lg. 6" dia. $95.00 each.

TEST SETS

TS-731/URM summation bridge complete with MX 1806/URM-20 bolometer mount set. 1kmc to 4kmc power measuring set. New $395 each.

TS-263A/TPS-10 X band F.M. signal generator, covers entire band. Includes wavemeter, thermistor bridge, calib. attenuator, regulated pwr supply. A complete source. Uses 2K25 osc. New $325.00.

TS743/U Signal generator. Covers 15,250 to 16,250mc. CW, pulse, FM. Calibrated attenuator. .1 to 2μ sec pulse widths. 1 to 100μ sec delay. 100 to 1000 cps range. —10 to —90 dbm. $975.

TS46/AP FREQUENCY METER complete 3000mc band coverage with accuracy of .5mc relative, absolute plus and minus 3mc. 200 microamp. meter. Micrometer adjust. Equal to TS-117. New $35.00.

TS35A/AP SIGNAL GENERATOR complete "X" band coverage. CW output 0 to —70dbm, peak pulse output plus 3 to —67dbm, 0 to 35db attenuator, 2K25 oscillator. Tuneable wavemeter. Temp. compensated power meas. circuit —10 to plus 33dbm. 115 vac 60 cy input. Price like new guaranteed $225.

TS193B/CPM4 DUMMY T-R BOX compl/w. "N" xtal mixer assy (tuneable) $37.50.

TS-270 S band 10cm echo box. Precision invar cavity unit with detector and meter resonance indicator. Direct reading. $175.00.

TS-207 S band 10cm echo box. w/calib. chart. $37.50 ea.

TS-311 X band 3cm echo box. 8720-8920 mcs. $85 ea.

TS-545 ECHO BOX: 1000mc "L" band complete coverage. High Q. Precision. Invar cavity. Crystal detector with microammeter personance indicator. $150 each.

TS-108 Type X band dummy load. 40kw peak. Std 1x½" guide. $25 ea.

LAE Signal generator. 500 to 1400 mcs. w/calib. attenuator and 115v 60cy ac pwr supply $325.

LAF Signal generator. 100 to 800 mcs w/calib attenuator & 115 v 60 cy ac pwr supply $325.

TS-130/UP "L" band slotted line for vswr measurements. 1⅞ coax. type "N" adaptor incl. $125.00.

CRYSTAL MIXERS

BROAD BAND BAL MIXER using short slot-hybrid. Pound type broad band dual balanced crystal holder. 1x.5 wg size. $25.00 new.

MIXER BLOCK: "N" input. "BNC" output, cplg loop. 1N21 series xtal. $15.00.

LOW LEVEL CONVERTER: "N" input. Tunable. Covers all S band. $7.50.

COAX MIXER ASSEMBLY S BAND IN21 type crystal detector RF to IF, 'N' fittings, matching Slug, duplex couplings, mf. G.E. New. $18.50.

PENCIL TYPE MIXER. Gold plated. 1N21 series crystal. "N" output/input. $17.50.

CRYSTAL MOUNTS

X BAND. Broad band. "BNC" output. UG39 flange input. $24.50.

S BAND: Type "N" input. ⅜ coax. Tuneable over entire band. $7.50.

FLEXIBLE WAVEGUIDE

1"x½"x4" $5.00 ea.
1"x½"x9" $10.00 ea.
1"x½"x24" $21.50 ea.

1¼"x⅝"x12" $19.50 ea.
3"x1½"x12" $55.00 ea.
3"x1½"x18" $65.00 ea.

3KW 400 CYCLE SOURCE

Complete generator set 115vdc 4HP motor (easily swapped for standard GE or other 115v 60 cycle AC motor) speed regulated. Generator output 115 volts 400 cycle single phase 17.4 amps continuous duty. Output electronically regulated. Built to rigid US Navy spec. In excellent condition. Price $225.00.

R.F. PACKAGES

RT39/APG-5 & 15 10CM RADAR. Complete S band RF package. Lighthouse 2C40 xmtr 500 watts peak. 2C43 rcvr, TR, 829B pulser, miniature 6AK5 IF strip. Press. 12" dia., 24" lg. New with tubes $275. Ref: MIT Rad. Lab. Series Vol. I, pg. 207.

APS-31A 3cm. RF head. 100kw output using 4J52 Magnetron. Complete with balanced mixer (2K25's) miniature 105db gain 60mc. IF strip, compl. receiver, pressurized housing. All tubes incl. As new. $395.00.

K BAND RF head. 24kmc, 60kw output. xmtr-rcvr w/modulator. 3J31 magnetron. magic T mixer. $750.

3CM 10kw output, 131db, gain rcvr. hydrogen thyr. modulator 810/405 pps .8/2.2μ sec. pulse. 31 tubes incl 2J42 magnetron. $375 complete. 45 lbs wt.

AN/SPT-6A TRANSMITTER

350 to 1400mc countermeasures jammer uses 3C22 in tuneable cavity. 50 watts output cw. 115V 60 cy AC input. New and complete operating unit. $450 each. New.

10CM ONE MEGAWATT: RF head and modulator (4C35). $1200 ea.

T51A/ARQ-8 25 to 105mc output. 30 watts cw. 115V 400cy AC input. As new. $75.00 ea.

SEE ALSO "RADAR SYSTEMS" FOR AD'T'L RF PACKAGES

PULSE MODULATORS

MIT Model 9 PULSER
1 MEGAWATT-HARD TUBE

Output pulse power 25KV at 40 amp. Max duty ratio: .002. Uses 6C21 pulse tube. Pulse duration .25 to 2 microsec. Input 115 volts 60 cycle AC. Includes power supply in separate cabinet and driver. Fully guaranteed as new condition. Full Desc. MIT. Rad. Lab. series "Pulse Generators." Vol. 5 pg. 152.

MIT MODEL 3 PULSER

Output: 144kw (12kv at 12 amp). Duty ratio: .001 max. Pulse duration: .5, 1 and 2 micro sec. Input: 115v 400 to 2000 cps and 24vdc. $325 ea. Full desc. Vol. 5 MIT Rad. Lab. series pg. 140.

2 MEGAWATT PULSER

Includes Rectifier xfmr 5800/7000V. 2.2/2.55-KVA; Resonant charging choke 150 cy. 30H 12 Amp. Ins. 17KV; Capacitor network 17E2-2-300-25P2T; Capacitor. 04Mfd. 17KVDC; Transformer 4400V to 22.000V; Fil. Xfmr. & Filter choke 5.1V 18Amp, 6 H .21Amp. DC; 4C35 pulser, 3B24W (6 each), WL1B41 gap tube. Price new type MD-53/APS20C $1125.00

PULSE TRANSFORMER: Raytheon U-12016 .3mu sec., rep. rate 1000 cycles. Pri: 3kv 64 amps pk. Sec: 12.5kv 9.5 amps pk. and 200v. Oil immersed. $24.50 each.

PULSE CABLE ASSEMBLY

AIR TO OIL (Rubber to ceramic). Apx 12" long. $8.50 ea.

AIR TO OIL (Rubber to ceramic). Apx 12" long. $3 ea.

KLYSTRONS—MAGNETRONS

SMX-32 Sperry Klystron Amplifier-Multiplier 9.0-10.5KMC. Amp. freq. multiplier; output power 1.5 to 2 watts at 9000 to 10,500mc; crystal stability drive freq. 4500 to 5250mc. New in original sealed cartons. Guaranteed 90 days. Regular price $925 ea. Our price $425 ea. 10% disc. on 2 or more.

SMC-11A Sperry Klystron Frequency multiplier. Output range 4640-4670mc. ½ to 1 watt on 6th harmonic. Crystal stability. Input range 773-778 (i.e. 2c39) mc. For direct control of microwave frequencies. New in original sealed cartons. Guaranteed 90 days. Regular price $1500 ea. Our price $495 ea. 10% disc. on 2 or more.

VARIAN KLYSTRON VA6312/V57. 8.5-10kmc 15mw output. shaft tuner. Factory new with spec. sheet. $125.00.

24KMC. PKG. MAGNETRON

3J21 Magnetron. 60kw output at 1.25cm. K band. 15kv 15 amp. input. Axial cathode mount. Waveguide output. Packaged with magnet. New $87.50 ea. gtd.

QK-60. S band cw, tubeable packaged magnetron with octal base and coax output $55 each.

4J50. X band, mg. Sylvania. packaged 250 kw output. freq. 9375 kmc ±30mc output. 1μ sec. duty .001 21.5kv at 27.5amp. New and guaranteed. $225 ea.

6406/QK428. S band one megawatt. Packaged. Waveguide output. $325 new and guaranteed.

2J53. A ruggedized 725A that will take a longer and harder pulse. Extended life and reliability. New guaranteed $110.50. Mfg. Litton Industries.

BENDIX GYRO SERVO UNIT. Combined horizon gyro. Autosyn & tilt correction motor. Maintains tilt stabilization of radar antenna, etc. Pioneer 12800-1-B. New $75.00.

EQUIPMENT VANS

Fully insulated, wired for 110vac with lights and outlets. Includes heater, thermostat controls. 20 ft. long apx, 8 ft. wide, 10 ft. high. Fifth wheel for hauling by std. truck tractor. Buttressed walls for handling high roof torsion. 1 entrance door, 2 equipment doors. 4 wheel rear axle. Will hold 10 tons of equipment. Elevator from van floor to roof incl. in some units. Exc. condition $2000 ea. Mfg. Freuheuf. Large quantity in stock.

WAVEGUIDE

RG52: 1"x½". per ft. $1.50.
RG51: 1¼"x⅝" per ft. $1.75.
RG48: 3"x1½" per ft. $3.00.
RG66: ½"x¼" per ft. $1.25.
RG96: .36x.22 coin silver. $3.50/ft.

RG44: ⅞" coax 12' lgths. 50 ohm 10 cm. Stub supported. $34.50 ea.

RG44: Right angle bends. $6 ea.

RG52: E plane 90° bend, 2½" radius. $10.50 silver plated. H plane 90° bend 2½" radius. $10.50 silver plated.

RG48: Cast mitred 90 deg bend. E or H plane with rect. std. flanges. $35 ea.

RG48: E plane bend less flgs. $12.50.

UG805/U: Rg 106/μ 1½"x¾" w/μg 440-441 flgs. 45 deg. mitred bend. $6.50.

UG741/U: Rg 106/μ 1½"x¾" w/μg 440-441 flgs. 45 deg. bend. $6.50 ea.

UG725/U: Rg 106/μ 1½"x¾" w/μg 440-441 flgs. 90 deg bend. $7.50 ea.

KIT of 15 asstd. 3cm aluminum waveguide pieces of various shapes and sizes. $5.00.

SUMMATION BRIDGE

TS 731/URM. Portable, general purpose, field type, ruggedized wattmeter used to measure R.F. power output of radio, radar & navigation equips. A direct reading summation type circuit in which a bolometer acts as one arm of a D.C. Wheatstone bridge, at the same time providing correct resistivity termination for R.F. entering the wattmeter. Power supply: 115VAC, 1 ph, 50-1600 cy. Freq. range: 1000 to 4000 mcs with plumbing supplied. VSWR less than 1.3. Gov't cost well over $1000 in large quantity. Your cost—$395 ea. Factory new.

ROTARY JOINTS

X BAND: Sperry apq36 joint. 1"x½". $15.00 ea.
X BAND: Sperry, with 3½" focal. Length cutler feed dipole 1"x½". $15.00 ea.
X BAND: 1¼"x⅝". $15.00 ea.
X BAND: Azimuth joint 1¼"x⅝" APS-15. $15.00 ea.
X BAND: Very high speed joint. Dalmo Victor. AN/APS-6. Stainless steel. $15.00.
S BAND: ⅞ coax rotary joint. Gold plated. P/O SCR584 antenna. $55.00.
L BAND: 1⅝" coax (no center cond) Western Electric. $15.00.

TRANSITIONS

RG48 TO ⅞ COAX. ADAPTER S Band 1½ x 3" W.G. to RG 44/U coax. $25.00 ea.

RG48 TO TYPE "N" ADAPTER. S band 1½" x 3" W.G. $21.50 ea.

RG51 TO RG52 (1¼" x ⅝" to 1" x ½") smooth taper. $16 ea.

RG51 TO RG52 FLEX. MAGNETRON cplg. $15 ea.

CAVITIES

2C40 Lighthouse cavity. Temperature compensated. Invar. S band tuneable over range (10cm). Maximum power capability. P/O AN/APW-11A. $77.50 each.

F-28/APN-19 FILTER CAVITY

Jan. spec: Tuneable 2700-2900mc, 1.5db max. loss at ctr freq over band. Details: Insertion loss variable. Single tuned filter for freq channelling in radar beacon. Invar center tuning conductor ¾ wavelength. New $37.50 each.

McNALLY Cavity. 2K28 or 707B. Solid coin silver. Tuneable over S band (10cm). $22.50 each.

2C40 Lighthouse Cavity. Temp. comp. brass. Tuneable over 10cm band. P/O AN/APN-60. $55.00 each.

1Q22 CAVITY. 9310 mcs. Beacon reference cavity. Mfg. Westinghouse. $17.50 ea.

RADIOSONDE RECORDER: RD-21/AM. Mfg. Times Famsimile Corp. A complete portable unit with 12" chart roll. $450.

GENERAL RADIO DECADE FREQUENCY CONTROL SYSTEM .1 to 10 mc. 6 ft rack. 110v 60cy AC input. $650.

WAVEGUIDE SWITCH. Mfg. Airtron. 3cm. spdt. vswr less than 1.1, att. less than .2db, Oper. voltage 10 to 16.5vdc. New $85.00 ea.

KLYSTRON MOUNTS

3CM. Precision Tube Mount. Waveline model 688. X band shielded klystron mount PRD signal generator type. Complete with variable glass vane attenuator. Brand new. $205. list. Price $45.00.

S. band. Type N output. Tunable over entire band. For Shepard type tube i.e. 726 w/socket & tube clamp. Mfg. GE. New. $15.00.

3 CM. KLYSTRON MOUNT

2K25-723A/B mount with cplg. to waveguide run and afc. Shielded incl tuning rod. Matching tuneable output slugs. Dual crystal mount. Pwr cable w/min. plug. Brand new. $28.50.

BALANCED MIXER—3CM. 2K25/723AB mount for local osc. & beacon. Incl. all matching slugs, crystal mounts, T-R coupling. $24.50 ea.

3.CM RADAR FRONT END. 2K25/723 ab dual mount with L.O./beacon cplg. via 2 hole coupler, 3 xtal mounts, matching slugs, variable glass vane attenuator. Ideal as bench set-up. $45 new.

I.F. STRIPS

GOMC IF. 130 DB GAIN. Ctr IF 60mc and 1.25mc Band width: long range search 1mc. Uses 6AK5's Complete with 15 tubes. $77.50 ea.

AFC UNIT FOR ABOVE: Follows freq shift at rate of 150mc/sec for .5 μsec pulse at rate of 25 mc/sec/sec for 5 μsec pulse. Sweep freq. range: 30mc about center freq. Sweep center variable FM —135 to —175 volts. $47.50 ea.

60 MC I.F. MINIATURE. Uses 6 ea. 6AK5 for gain of 100db with 2mc band width. Wt. 9 oz. Less tubes. $24.50.

30 MC I.F. Uses 6 ea. 6AC7. Overall gain 95db. Bandwidth apx 2 mc. Wt. apx 3 lbs. Less tubes. $27.50.

DIRECTIONAL COUPLERS

X BAND. 35 db. Measures transmitted and reflected power. Cross guide type. Std flanges. Airtron. Dual type "N" output. 1″x½″ guide. $19.50.

X BAND. CG 176/AP 20 db. Unidir. cplr. "N" output. Std. flanges. 1″x½″ guide. $15.00.

X BAND. 24 db. Bi-directional 1¼″x⅝″ guide. Type "N" output. Std. flanges. $22.50 ea.

S BAND. 27 db. Uni-directional, box type. "N" output. 3″x1½″ guide. Std. flgs. $32.50 ea.

SPERRY MICROLINE

ATTENUATOR. Model 127. 30mc. $85.00.

DOUBLE SLUG TUNER, Model 363 with 2700-3700 mc line. $125.00.

TELEPHONE CARRIER

We carry a full stock of telephone carrier and parts. 1C filters, equalizers, retards, etc. For AN/TCC-7, CF-1A, CF-2B, Western Electric type "C," etc.

2.5 KW PRESS WIRELESS XMTR. Type PW-981A 2-23 mc. cw and freq. shift (teletype) MO 25 XTAL channels. Complete. $750.00.

RADAR SYSTEMS

3 & 10 CM SCR 584
AUTOMATIC TRACKING RADARS

Ten or three cm. operation. Full automatic tracking, search, lock-on search radar system. Full azimuth and elevation antenna sweep with servo/amplidyne control. P.P.I. indication. Computes range, azimuth, slant range with data output set up to be fed to a computer or tape. Nutating feed dipole. All in mobile, insulated, heated trailer 20 feet long with elevator for driving antenna up to roof.

Our 584s in like new condition, ready to go, and in stock for immediate delivery. Ideal for research and development, airway control, GCA, missile tracking, balloon tracking, weather forecasting, antiaircraft defense, tactical air support. Write us. Fully Desc. MIT Rad. Lab. Series, Vol. I, pps. 207-210, 228, 284-[illegible]

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AN/MPN-1B GCA SET

Ground control approach equipped trailer with 3 cm precision and 10 cm search radars plus full complement precision and search indicators. All in original trailer. Call—write for info. and price. Fully Desc. MIT Rad. Lab. Series, Vol. II, pps. 237-251. Like new.

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AN/FPN-32 GCA RADAR

Lab. for Electronics "Quad" type portable ground control approach radar system. 3cm. search and precision approach. Complete systems in used, good condition. A very late type system—in stock $5500 ea. Exc. cond.

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10 CM. WEATHER RADAR SYSTEM

US Navy Raytheon 275 KW peak output S band. Rotating yoke Plan position Indicator. Magnetron supplied for any S band frequency specified, incl. Weather Band. 4, 20 and 80 mile range. 360 degree azimuth scan. Sensitive rcvr using 2K28/707B and 1N21B. Supplied brand new complete with instruction books and installation drawings. Can be supplied to operate from 32VDC or 115 volts. Price $975. Ideal for weather work. Has picked up clouds at 50 miles. Weight 448 lbs. New.

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AN/APS-10 3 CM. RADAR

Complete X band system. Uses 2J42 magnatron, hyd. thyr. pulser. 105 db gain IF, 30 μc IF. PPI scope, 360 deg rotating ant. Fully desc. MIT Rad. Lab. series, Vol. I pp. 616-625 and Vol. II pps. 171-185. Similar to $17,000 weather-navigation radar now in use by airlines. $750 ea. Complete. Like new.

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WESTINGHOUSE 3CM RADAR: Complete X band system oper. from 115v 60cy ac with 40kw power output 2J55 magetron. Ranges 0-1.5, 4, 16, 40 miles. Includes installation waveguide. An ideal system for lab school, demonstration or shipboard. $1800. New with spares.

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AN/APS-15B 3CM RADAR

Airborne radar. 40kw output using 725A magnetron. Model 3 pulser. 30 in. parabola stabilized antenna. PPI scope. Complete system. $1200 each. New.

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AN/CPN-6 3CM RADAR BEACON

GND. Installation. 40kw output. 4PR60A/715B pulse modulator. Contained in 2 cabinets. 115v 60cy ac input. Complete instalaltion access and spares.

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AN/APN-19 & 60 RADAR BEACON

10cm lighthouse osc. 2C40, low level converter receiver. Used for extending range of radars such as SCR584. Radar triggers beacon which emits 500 watt peak echo pulse. Complete $275. Transmitter only $175. Receiver only $95. Power unit only $35.

74 to 320 MC BUTTERFLY TUNER

Rotates thru 360 deg. either hand or motor driveable. Ball bearing mounted rotor. New. $22.50 ea.

VIDEO INDICATORS

VD-2 PPI REPEATER. Floor standing console with rotating yoke PPI. 7BP7CRT. 4, 20, 80, 200 mile ranges. Will display or repeat any PPI info locally for remote. New & complete. With inst. book. $375 ea.

VG PROJECTION PPI CONSOLE: Will take any video PPI info, repeat and project on 28″ square desk type console. Mfg. G.E. Ideal as plotting board, etc. Weighs 850 lbs complete. $350 ea.

AN/CPS-1 PPI INDICATOR: Console for 12″ CRT PPI comp. w/power supply—110v 60cy ac. $225 new.

HYBRIDS

TOPWALL HYBRID JUNCTION. 8500-9600mc 1x.5 wg size. Broad banded better than 16%. Aluminum casting. $15.00 new. Crossover output, 1x.5 wg size. $5.00 new.

BROAD BAND BAL MIXER using short slot-hybrid. Pound type broad band dual balanced crystal holder. 1x.5 wg size. $25.00 new.

DIPOLES

3CM: 180 degree feedback horn. VSWR .1db pressurized window. Length 6½″. Focal length 2½″. Std flg. 1″x½″ waveguide. $18.50 ea.

3CM: Dipole feed, feedback dipole. Sperry 6″ focal lgth. $5.

10CM: ⅞″ coax feedback dipole. 9″ focal length. $5.

10CM: Nutating feed dipole P/O scr 58 ant. $55.00.

ANTENNA

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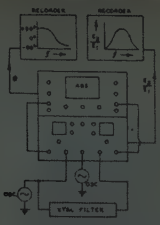

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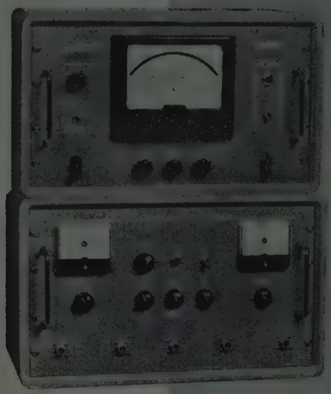

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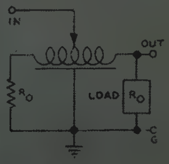

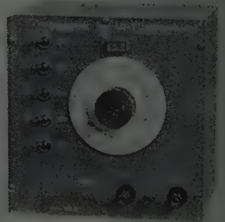

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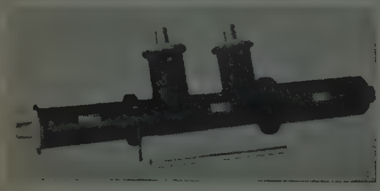

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DAGE offers facilities for the design, production and testing of coaxial and triaxial connectors and precision hermetic seals. The new DAGE Facilities Brochure gives full details . . .

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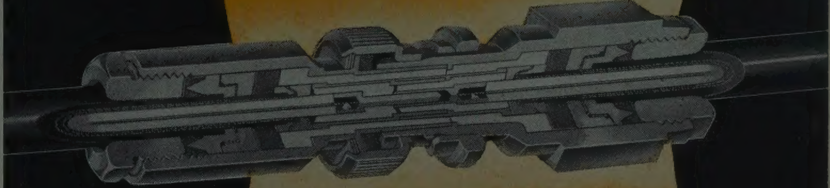
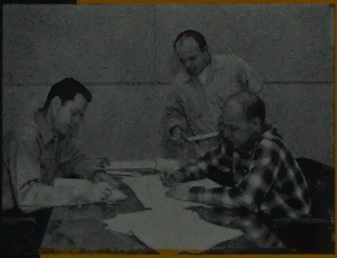
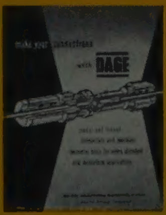
Beech Grove, Indiana



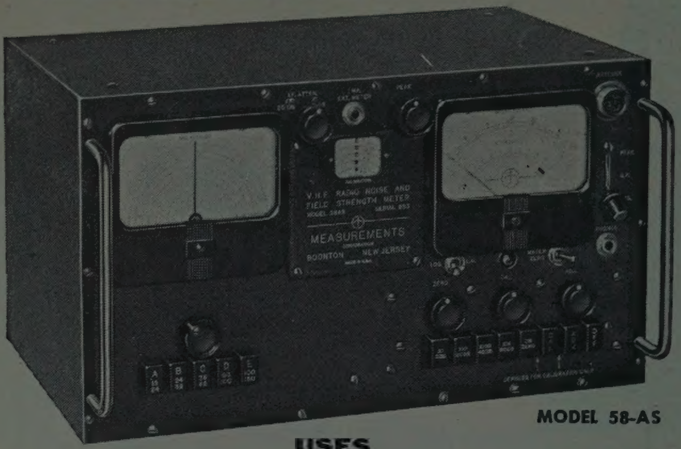




MEASUREMENTS' *improved*

VHF Radio Noise and Field Strength Meter

FREQUENCY RANGE 15 MC TO 150 MC



MODEL 58-AS

USES

- For measuring electrical noise
- As a tuned r-f voltmeter
- As a null indicator for r-f bridges and slotted lines
- For directional-antenna pattern measurements
- For signal-to-noise ratio measurements
- For measurement of harmonics
- As a carrier-voltage meter
- As a field-strength meter

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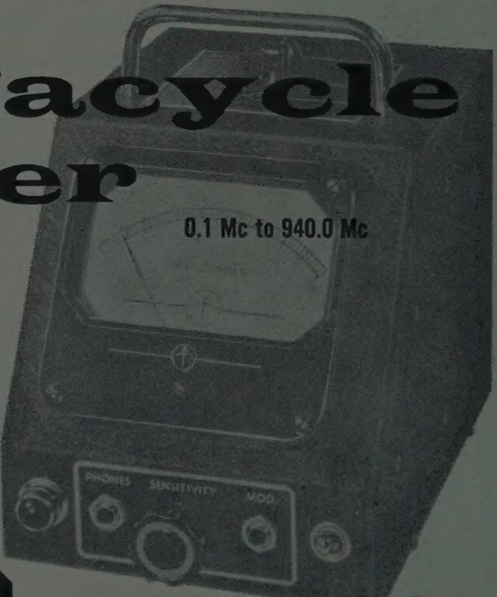
Laboratory Standards

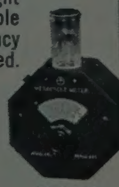
MEASUREMENTS
A McGraw-Edison Division
BOONTON, NEW JERSEY

Megacycle Meter

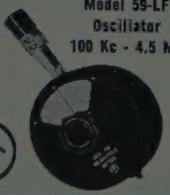


Determines resonant frequency of tuned circuits, antennas, transmission lines, by-pass condensers, chokes, etc. Measures inductance and capacitance. Also used as a signal generator, wave meter, frequency meter, and in many other applications.

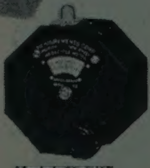
This compact, lightweight grid-dip meter is available in the frequency ranges indicated.



Model 59
Oscillator
2.2 Mc - 420 Mc



Model 59-LF
Oscillator
100 Kc - 4.5 Mc



Model 59-UHF
Oscillator
420 Mc - 940 Mc

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A McGraw-Edison Division
BOONTON, NEW JERSEY

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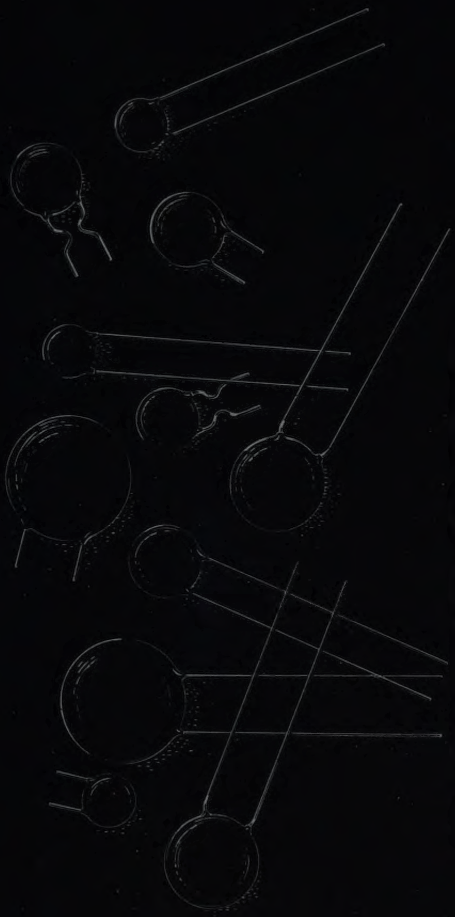
Consistently Dependable Capacitors

TINY MIKE®

Cornell-Dubilier's low-inductance ceramic-disc capacitor for transistorized applications



Tiny Mike miniature ceramic disc capacitors are designed to meet the limited-space, low-voltage requirements of portable transistorized radios and a wide variety of other miniature battery-powered and line-powered equipment. Especially applicable for bypass and coupling use, their tough phenolic coating and high-temperature wax impregnation provide excellent insulation, protect against high humidity and severe vibration. Immediately available in production quantities.

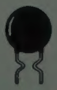
For detailed information and engineering assistance, write for Bulletin SEB-2 to Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. *Manufacturers of consistently dependable capacitors, filters and networks for electronics, thermonucleonics, broadcasting and utility use for 50 years.*

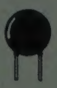
SPECIFICATIONS AND FEATURES

Capacitance values available: .005, .01, .02, .05, and .1 mfd.

Diameters: .350″ to .625″

Working Voltage: 50 VDC



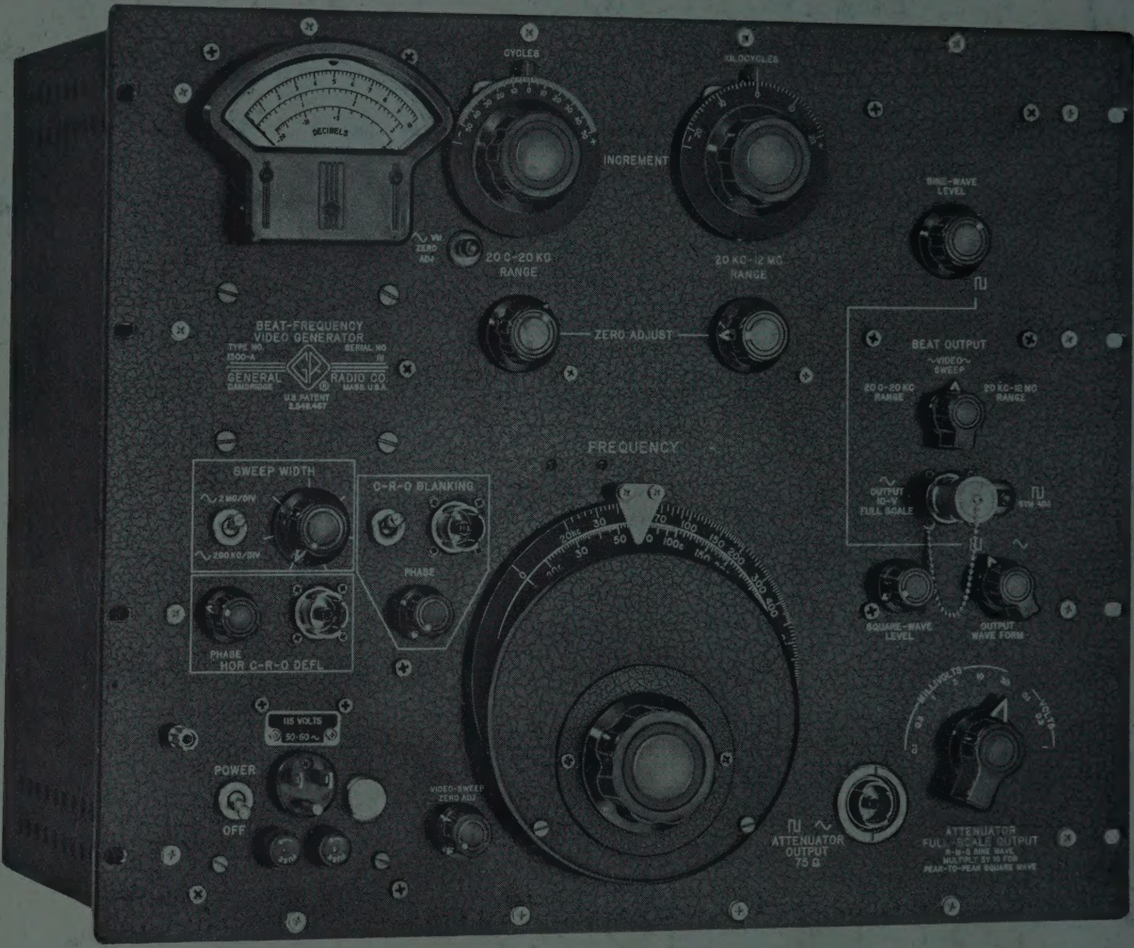


Crimped and Straight-Cut Leads for Automation. These units are available in 600 and 1000 VDCW ratings on types C, JA, JB, JC, BYA and other general purpose capacitors. Leads are accurately spaced for easy insertion into printed wiring boards. Crimped leads prevent bottoming on printed wiring boards, assuring positive contact for soldering. Straight-cut leads save height off the board and may be inserted to circumference of disc. Controlled phenolic dip avoids "rundown" of the phenolic on straight-cut leads. Assures always-uniform soldered connections.

CDE **CORNELL-DUBILIER ELECTRIC CORPORATION**

AFFILIATED WITH FEDERAL PACIFIC ELECTRIC COMPANY

NEW 20c to 12-Mc Beat-Frequency Generator for Sine/Square-Wave and Sweep Applications


CYCLES
KILOCYCLES
DECIBELS
INCREMENT
SINE-WAVE LEVEL
ZERO ADJ
20 C-20 KC RANGE
20 KC-12 MC RANGE
ZERO ADJUST
BEAT-FREQUENCY VIDEO GENERATOR
TYPE NO. 1300-A
SERIAL NO.
GENERAL RADIO CO.
CAMBRIDGE MASS. U.S.A.
U.S. PATENT 2,548,457
BEAT OUTPUT
VIDEO SWEEP
FREQUENCY
SWEEP WIDTH
2 MC/DIV
200 KC/DIV
C-R-O BLANKING
PHASE
HOR C-R-O DEFL
OUTPUT 10 V FULL SCALE
SQUARE-WAVE LEVEL
OUTPUT WAVE FORM
MILLIVOLTS
VOLTS
115 VOLTS 50-60 ~
POWER
OFF
VIDEO-SWEEP ZERO ADJ
ATTENUATOR OUTPUT 75 Ω
ATTENUATOR FULL-SCALE OUTPUT

The features of beat-frequency generators, so well liked for audio-frequency testing, are now available for ultrasonic and video-frequency work. Features include: complete audio- or video-band coverage in one sweep of the dial without annoying range switching . . . high resolution provided by incremental frequency dials for accurate point-by-point studies of amplitude peaks and dips . . . continuously adjustable electronic sweep for video measurements at center frequencies to 12 Mc . . . automatic graphic-level and x-y recording with accessory G-R Dial Drives . . . square-wave output for frequency-response testing by transient techniques (e.g., rise-time and ramp-off measurements) . . . adjustable ± 6-Mc sweep at center frequencies from 36 to 42 Mc (obtained directly from internal oscillators) for television i-f testing.

This instrument's many outputs and different modes of operation, coupled with excellent frequency stability and high output (10v) over the entire frequency range, make it the most versatile audio-video test instrument commercially available.

Type 1300-A Beat-Frequency Video Generator . . . $1950

As Manually-Tuned Generator:
Sine Wave: 20c to 12 Mc
Square Wave: 20c to 2 Mc

As Sweep Generator (60c sweep rate):
Sine Wave: 20 kc to 12 Mc
Sweep width is continuously adjustable from 0 to ±6 Mc at any center frequency from 0 to 12 Mc.
Horizontal deflection voltage and blanking pulse provided for scopes.

Calibration Accuracy:
20c to 20 kc, ±(1% + 1c)
20 kc to 500 kc, ±(2% + 1 kc)
500 kc to 12 Mc, ±(1% + 1 kc)

In addition to the main frequency dia two increment dials calibrated fro −50c to +50c, and −20 kc to +20 k are provided. Calibration accuracie are ±1c and ±0.5 kc, respectively.

Sine Wave — harmonic distortion
20c to 20 kc: < 1.5% of output
20 kc to 12 Mc: < 4% of output

Square Wave
Rise time less than 0.075 μsec above 300 kc
Top flat to 2% of peak-to-peak at 60c, 5% at 20c.

Hum: less than 0.1% of output

	Voltage Range		Accuracy	Frequency Characteristic	Output Impedance
	Sine-Wave (rms)	Square-Wave (peak-to-peak)			
Attenuator output	0.1, 0.3, 1, 3, 10, and 30 mv; 0.1, 0.3, and 1v full scale, open circuit	1, 3, 10, 30, 100, and 300 mv; 1, 3, and 10v	±3% of full scale; attenuator db increments ±1%	flat within ±0.25 db from 40c to 20 kc (±0.75 db at 20c); ±1 db from 20 kc to 12 Mc	75Ω ± 2%
High output	0 to 10v	0 to 10v	±3% of full scale	flat within ±0.25 db from 20c to 20 kc; ±1 db from 20 kc to 12 Mc (open circuit)	820Ω ± 2%

AT THE IRE SHOW

Booth Nos. 3201 to 3208

See a Typical Standards and Measurements Laboratory in Operation . . . Impedance Measurements from D-C to Microwave Frequencies

The New Beat-Frequency Generator Will Be on Display as well as many other instruments

Write for complete information

GENERAL RADIO COMPANY

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